```
stars by prs  for s/w 2b

6077/

/stars 1 • 3/13/62, prs.

        decimal

        define
mark X, Y
        repeat 8, Y=Y+Y
        8192-X     Y
        terminate

1j,     mark 1537, 371      /87 Taur, Aldebaran
        mark 1762, -189     /19 Orio, Rigel
        mark 1990, 168      /58 Orio, Betelgeuze
        mark 2280, -377     /9 CMaj, Sirius
        mark 2583, 125      /10 CMin, Procyon
        mark 3431, 283      /32 Leon, Regulus
        mark 4551, -242     /67 Virg, Spica
        mark 4842, 448      /16 Boot, Arcturus
1q,     mark 6747, 196      /53 Aqil, Altair

2j,     mark 1819, 143      /24 Orio, Bellatrix
        mark 1884, -29      /46 Orio
        mark 1910, -46      /50 Orio
        mark 1951, -221     /53 Orio
        mark 2152, -407     / 2 CMaj
        mark 2230, 375      /24 Gemi
        mark 3201, -187     /30 Hyda, Alphard
        mark 4005, 344      /94 Leon, Denebola
2q,     mark 5975, 288      /55 Ophi

3j,     mark   46, 333      /88 Pegs, Algenib
        mark  362, -244     /31 Ceti
        mark  490, 338      /99 Pisc
        mark  566, -375     /52 Ceti
        mark  621, 462      / 6 Arie
        mark 764, -78       /68 Ceti, Mira
        mark  900, 64       /86 Ceti
        mark 1007, 84       /92 Ceti
        mark 1243, -230     /23 Erid
        mark 1328, -314     /34 Erid
        mark 1495, 432      /74 Taur
        mark 1496, 356      /78 Taur
        mark 1618, 154      / 1 Orio
        mark 1644, 52       / 8 Orio
        mark 1723, -119     /67 Erid
        mark 1755, -371     / 5 Leps
        mark 1779, -158     /20 Orio
        mark 1817, -57      /28 Orio
        mark 1843, -474     / 9 Leps
        mark 1860, -8       /34 Orio
        mark 1868, -407     /11 Leps
        mark 1875, 225      /39 Orio
        mark 1880, -136     /44 Orio
        mark 1887, 480      /123 Taur
        mark 1948, -338     /14 Leps
        mark 2274, 296      /31 Gemi
```

mark 2460, 380   /54 Gemi

```
          mark 2470, 504       /55 Gemi
          mark 2513, 193       / 3 CMin
          mark 2967, 154       /11 Hyda
          mark 3016, 144       /16 Hyda
          mark 3424, 393       /30 Leon
          mark 3496, 463       /41 Leon, Algieba
          mark 3668, -357      /nu Hyda
          mark 3805, 479       /68 Leon
          mark 3806, 364       /10 Leon
          mark 4124, -502      / 2 Corv
          mark 4157, -387      / 4 Corv
          mark 4236, -363      / 7 Corv
          mark 4304, -21       /29 Virg
          mark 4384, 90        /43 Virg
          mark 4421, 262       /47 Virg
          mark 4606, -2        /79 Virg
          mark 4721, 430       / 8 Boot
          mark 5037, -356      / 9 Libr
          mark 5186, -205      /27 Libr
          mark 5344, 153       /24 Serp
          mark 5357, 358       /28 Serp
          mark 5373, -71       /32 Serp
          mark 5430, -508      / 7 Scor
          mark 5459, -445      / 8 Scor
          mark 5513, -78       / 1 Ophi
          mark 5536, -101      / 2 Ophi
          mark 5609, 494       /27 Herc
          mark 5641, -236      /13 Ophi
          mark 5828, -355      /35 Ophi
          mark 5860, 330       /64 Herc
          mark 5984, -349      /55 Serp
          mark 6047, 63        /62 Ophi
          mark 6107, -222      /64 Ophi
          mark 6159, 217       /72 Ophi
          mark 6236, -66       /58 Serp
          mark 6439, -483      /37 Sgtr
          mark 6490, 312       /17 Aqil
          mark 6491, -115      /16 Aqil
          mark 6507, -482      /41 Sgtr
          mark 6602, 66        /30 Aqil
          mark 6721, 236       /50 Aqil
          mark 6794, 437       /12 Sgte
          mark 6862, -25       /65 Aqil
          mark 6914, -344      / 9 Capr
          mark 7014, 324       / 6 Dlph
          mark 7318, -137      /22 Aqar
          mark 7391, 214       / 8 Pegs
          mark 7404, -377      /49 Capr
          mark 7513, -18       /34 Aqar
          mark 7539, 130       /26 Pegs
          mark 7644, -12       /55 Aqar
          mark 7717, 235       /42 Pegs
          mark 7790, -372      /76 Aqar
3q,       mark 7849, 334       /54 Pegs, Markab
```

```
4j,      mark    1, -143    /33 Pisc
         mark   54, 447     /89 Pegs
         mark   54, -443    / 7 Ceti
         mark   82, -214    / 8 Ceti
         mark  223, -254    /17 Ceti
         mark  248, 160     /63 Pisc
         mark  273, -38     /20 Ceti
         mark  329, 167     /71 Pisc
         mark  376, 467     /84 Pisc
         mark  450, -198    /45 Ceti
         mark  548, 113     /106 Pisc
         mark  570, 197     /110 Pisc
         mark  595, -255    /53 Ceti
         mark  606, -247    /55 Ceti
         mark  615, 428     / 5 Arie
         mark  617, 61      /14 Pisc
         mark  656, -491    /59 Ceti
         mark  665, 52      /113 Pisc
         mark  727, 191     /65 Ceti
         mark  803, -290    /72 Ceti
         mark  813, 182     /73 Ceti
         mark  838, -357    /76 Ceti
         mark  878, -2      /82 Ceti
         mark  907, -340    /89 Ceti
         mark  908, 221     /87 Ceti
         mark  913, -432    / 1 Erid
         mark  947, -487    / 2 Erid
         mark  976, -212    / 3 Erid
         mark  992, 194     /91 Ceti
         mark 1058, 440     /57 Arie
         mark 1076, 470     /58 Arie
         mark 1087, -209    /13 Erid
         mark 1104, 68      /96 Ceti
         mark 1110, -503    /16 Erid
         mark 1135, 198     / 1 Taur
         mark 1148, 214     / 2 Taur
         mark 1168, 287     / 5 Taur
         mark 1170, -123    /17 Erid
         mark 1185, -223    /18 Erid
         mark 1191, -500    /19 Erid
         mark 1205, 2       /10 Taur
         marc 1260, -283    /26 Erid
         mark 1304, -74     /32 Erid
         mark 1338, 278     /35 Taur
         mark 1353, 130     /38 Taur
         mark 1358, 497     /37 Taur
         mark 1405, -162    /38 Erid
         mark 1414, 205     /47 Taur
         mark 1423, 197     /49 Taur
         mark 1426, -178    /40 Erid
         mark 1430, 463     /50 Taur
         mark 1446, 350     /54 Taur
         mark 1463, 394     /61 Taur
         mark 1470, 392     /64 Taur
         mark 1476, 502     /65 Taur
         mark 1477, 403     /68 Taur
mark 1483, 350      /71 Taur
mark 1485, 330      /73 Taur
mark 1495, 358      /77 Taur
mark 1507, 364      /
mark 1518, -6       /45 Erid
mark 1526, 333      /86 Taur
mark 1537, 226      /88 Taur
mark 1544, -81      /48 Erid
mark 1551, 280      /90 Taur
mark 1556, 358      /92 Taur
mark 1557, -330     /53 Erid
mark 1571, -452     /54 Erid
mark 1596, -78      /57 Erid
mark 1622, 199      / 2 Orio
mark 1626, 124      / 3 Orio
mark 1638, -128     /61 Erid
mark 1646, 228      / 7 Orio
mark 1654, 304      / 9 Orio
mark 1669, 36       /10 Orio
mark 1680, -289     /64 Erid
mark 1687, -167     /65 Erid
mark 1690, -460     /
mark 1690, 488      /102 Taur
mark 1700, 347      /11 Orio
mark 1729, 352      /15 Orio
mark 1732, -202     /69 Erid
mark 1750, -273     / 3 Leps
mark 1753, 63       /17 Orio
mark 1756, -297     / 4 Leps
mark 1792, -302     / 6 Leps
mark 1799, -486     /
mark 1801, -11      /22 Orio
mark 1807, 79       /23 Orio
mark 1816, -180     /29 Orio
mark 1818, 40       /25 Orio
mark 1830, 497      /114 Taur
mark 1830, 69       /30 Orio
mark 1851, 134      /32 Orio
mark 1857, 421      /119 Taur
mark 1861, -168     /36 Orio
mark 1874, 214      /37 Orio
mark 1878, -138     /
mark 1880, -112     /42 Orio
mark 1885, 210      /40 Orio
mark 1899, -60      /48 Orio
mark 1900, 93       /47 Orio
mark 1900, -165     /49 Orio
mark 1909, 375      /126 Taur
mark 1936, -511     /13 Leps
mark 1957, 287      /134 Taur
mark 1974, -475     /15 Leps
mark 1982, 461      /54 Orio
mark 2002, -323     /16 Leps
mark 2020, -70      /
mark 2030, 220      /61 Orio
mark 2032, -241     / 3 Mono
mark 2037, 458      /62 Orio
mark 2057, -340     /18 Leps
mark 2059, 336      /67 Orio
mark 2084, 368      /69 Orio
mark 2084, 324      /70 Orio
mark 2105, -142     / 5 Mono
mark 2112, -311     /
mark 2153, 106      / 8 Mono
mark 2179, 462      /18 Gemi
mark 2179, -107     /10 Mono
mark 2184, -159     /11 Mono
mark 2204, 168      /13 Mono
mark 2232, -436     / 7 CMaj
mark 2239, -413     / 8 CMaj
mark 2245, -320     /
mark 2250, 227      /15 Mono
mark 2266, 303      /30 Gemi
mark 2291, 57       /18 Mono
mark 2327, 303      /38 Gemi
mark 2328, -457     /15 CMaj
mark 2330, -271     /14 CMaj
mark 2340, -456     /19 CMaj
mark 2342, -385     /20 CMaj
mark 2378, -93      /19 Mono
mark 2379, 471      /43 Gemi
mark 2385, -352     /23 CMaj
mark 2428, -8       /22 Mono
mark 2491, -429     /
mark 2519, 208      / 4 CMin
mark 2527, 278      / 6 CMin
mark 2559, -503     /
mark 2597, -212     /26 Mono
mark 2704, -412     /
mark 2709, -25      /28 Mono
mark 2714, 60       /
mark 2751, -61      /29 Mono
mark 2757, -431     /16 Pupp
mark 2768, -288     /19 Pupp
mark 2794, 216      /17 Canc
mark 2848, -82      /
mark 2915, 138      / 4 Hyda
mark 2921, 84       / 5 Hyda
mark 2942, -355     / 9 Hyda
mark 2944, 497      /43 Canc
mark 2947, 85       / 7 Hyda
mark 2951, -156     /
mark 2953, 421      /47 Canc
mark 2968, -300     /12 Hyda
mark 2976, 141      /13 Hyda
mark 3032, 279      /65 Canc
mark 3124, 62       /22 Hyda
mark 3157, -263     /26 Hyda
mark 3161, -208     /27 Hyda
mark 3209, -53      /31 Hyda
mark 3225, -17      /32 Hyda
mark 3261, 116      /
mark 3270, -16        /35 Hyda
mark 3274, -316       /38 Hyda
mark 3276, 236        /14 Leon
mark 3338, -327       /39 Hyda
mark 3385, 194        /29 Leon
mark 3415, -286       /40 Hyda
mark 3428, 239        /31 Leon
mark 3429, 3          /15 Sext
mark 3446, -270       /41 Hyda
mark 3495, 455        /40 Leon
mark 3534, -372       /42 Hyda
mark 3557, -3         /30 Sext
mark 3570, 223        /47 Leon
mark 3726, -404       /al Crat
mark 3736, -44        /61 Leon
mark 3738, 471        /60 Leon
mark 3754, 179        /63 Leon
mark 3793, -507       /11 Crat
mark 3821, -71        /74 Leon
mark 3836, -324       /12 Crat
mark 3846, 150        /77 Leon
mark 3861, 252        /78 Leon
mark 3868, -390       /15 Crat
mark 3935, -211       /21 Crat
mark 3936, -6         /91 Leon
mark 3981, -405       /27 Crat
mark 3986, 161        / 3 Virg
mark 3998, 473        /93 Leon
mark 4013, 53         / 5 Virg
mark 4072, 163        / 8 Virg
mark 4097, 211        / 9 Virg
mark 4180, -3         /15 Virg
mark 4185, 418        /11 Coma
mark 4249, -356       / 8 Corv
mark 4290, -170       /26 Virg
mark 4305, 245        /30 Virg
mark 4376, -205       /40 Virg
mark 4403, 409        /36 Coma
mark 4465, -114       /51 Virg
mark 4466, 411        /42 Coma
mark 4512, -404       /61 Virg
mark 4563, -352       /69 Virg
mark 4590, -131       /74 Virg
mark 4603, 95         /78 Virg
mark 4679, 409        / 4 Boot
mark 4691, 371        / 5 Boot
mark 4759, 46         /93 Virg
mark 4820, 66         /
mark 4822, -223       /98 Virg
mark 4840, -126       /99 Virg
mark 4857, -294       /100 Virg
mark 4864, 382        /20 Boot
mark 4910, -41        /105 Virg
mark 4984, 383        /29 Boot
mark 4986, 322        /30 Boot
mark 4994, -119       /107 Virg
mark 5009, 396     /35 Boot
mark 5013, 53      /109 Virg
mark 5045, 444     /37 Boot
mark 5074, -90     /16 Libr
mark 5108, 57      /110 Virg
mark 5157, -442    /24 Libr
mark 5283, -221    /37 Libr
mark 5290, -329    /38 Libr
mark 5291, 247     /13 Serp
mark 5326, -440    /43 Libr
mark 5331, 455     /21 Serp
mark 5357, 175     /27 Serp
mark 5372, 420     /35 Serp
mark 5381, 109     /37 Serp
mark 5387, 484     /38 Serp
mark 5394, -374    /46 Libr
mark 5415, 364     /41 Serp
mark 5419, -318    /48 Libr
mark 5455, -253    /xi Scor
mark 5467, -464    / 9 Scor
mark 5470, -469    /10 Scor
mark 5497, -437    /14 Scor
mark 5499, -223    /15 Scor
mark 5558, 29      /50 Serp
mark 5561, 441     /20 Herc
mark 5565, -451    / 4 Ophi
mark 5580, 325     /24 Herc
mark 5582, -415    / 7 Ophi
mark 5589, -186    / 3 Ophi
mark 5606, -373    / 8 Ophi
mark 5609, 50      /10 Ophi
mark 5610, -484    / 9 Ophi
mark 5620, 266     /29 Herc
mark 5713, -241    /20 Ophi
mark 5742, 235     /25 Ophi
mark 5763, 217     /27 Ophi
mark 5807, 293     /60 Herc
mark 5868, -8      /41 Ophi
mark 5888, -478    /40 Ophi
mark 5889, -290    /53 Serp
mark 5924, -114    /
mark 5925, 96      /49 Ophi
mark 5987, -183    /57 Ophi
mark 6006, -292    /56 Serp
mark 6016, -492    /58 Ophi
mark 6117, -84     /57 Serp
mark 6117, 99      /66 Ophi
mark 6119, 381     /93 Herc
mark 6119, 67      /67 Ophi
mark 6125, 30      /68 Ophi
mark 6146, 57      /70 Ophi
mark 6158, 198     /71 Ophi
mark 6170, 473     /102 Herc
mark 6188, -480    /13 Sgtr
mark 6234, 76      /74 Ophi
mark 6235, 499     /106 Herc
mark 6247, -204     /xi Scut
mark 6254, -469     /21 Sgtr
mark 6255, 494      /109 Herc
mark 6278, -333     /ga Scut
mark 6313, -189     /al Scut
mark 6379, 465      /110 Herc
mark 6382, -110     /be Scut
mark 6386, 411      /111 Herc
mark 6436, 93       /63 Serp
mark 6457, 340      /13 Aqil
mark 6465, -134     /12 Aqil
mark 6478, -498     /39 Sgtr
mark 6553, 483      / 1 Vulp
mark 6576, -410     /44 Sgtr
mark 6576, -368     /46 Sgtr
mark 6607, 3        /32 Aqil
mark 6651, 163      /38 Aqil
mark 6657, 445      / 9 Vulp
mark 6665, -35      /41 Aqil
mark 6688, 405      / 5 Sgte
mark 6693, 393      / 6 Sgte
mark 6730, 416      / 7 Sgte
mark 6739, 430      / 8 Sgte
mark 6755, 17       /55 Aqil
mark 6766, 187      /59 Aqil
mark 6772, 140      /60 Aqil
mark 6882, 339      /67 Aqil
mark 6896, -292     / 5 Capr
mark 6898, -292     / 6 Capr
mark 6913, -297     / 8 Capr
mark 6958, -413     /11 Capr
mark 6988, 250      / 2 Dlph
mark 7001, 326      / 4 Dlph
mark 7015, -33      /71 Aqil
mark 7020, 475      /29 Vulp
mark 7026, 354      / 9 Dlph
mark 7047, 335      /11 Dlph
mark 7066, 359      /12 Dlph
mark 7067, -225     / 2 Aqar
mark 7068, -123     / 3 Aqar
mark 7096, -213     / 6 Aqar
mark 7161, -461     /22 Capr
mark 7170, -401     /23 Capr
mark 7192, -268     /13 Aqar
mark 7199, 222      / 5 Equl
mark 7223, 219      / 7 Equl
mark 7230, 110      / 8 Equl
mark 7263, -393     /32 Capr
mark 7267, 441      / 1 Pegs
mark 7299, -506     /36 Capr
mark 7347, -453     /39 Capr
mark 7353, -189     /23 Aqar
mark 7365, -390     /40 Capr
mark 7379, -440     /43 Capr
mark 7394, 384      / 9 Pegs
mark 7499, -60      /31 Aqar
mark 7513, 104      /22 Pegs
```

```
        mark 7515, -327     /33 Aqar
        mark 7575, -189     /43 Aqar
        mark 7603, -43      /48 Aqar
        mark 7604, 266      /31 Pegs
        mark 7624, 20       /52 Aqar
        mark 7639, 96       /35 Pegs
        mark 7654, -255     /57 A ar
        mark 7681, -14      /62 Aqar
        mark 7727, -440     /66 Aqar
        mark 7747, 266      /46 Pegs
        mark 7761, -321     /71 Aqar
        mark 7779, -185     /73 Aqar
        mark 7795, 189      /50 Pegs
        mark 7844, 75       / 4 Pisc
        mark 7862, 202      /55 Pegs
        mark 7874, -494     /88 Aqar
        mark 7903, -150     /90 Aqar
        mark 7911, -219     /91 Aqar
        mark 7919, 62       / 6 Pisc
        mark 7923, -222     /93 Aqar
        mark 7952, -470     /98 Aqar
        mark 7969, -482     /99 Aqar
        mark 7975, 16       / 8 Pisc
        mark 7981, 133      /10 Pisc
        mark 7988, 278      /70 Pegs
        mark 8010, -489     /101 Aqar
        mark 8049, 116      /17 Pisc
        mark 8059, -418     /104 Aqar
        mark 8061, 28       /18 Pisc
        mark 8064, -344     /105 Aqar
        mark 8159, 144      /28 Pisc
        mark 8174, -149     /30 Pisc
4q,     mark 8188, -407     / 2 Ceti

        start 4
```

```
/title punch table

ftp/     0                 0            004277       400000
         625151            514600       224145       453200
         141211            771000       274545       453100
         364545            453000       010171       050300
         324545            453200       065151       513600
         0                 0            0            0
         0                 0            0            0
         0                 0            0            0

         364141            413600       402014       020100
         224545            453000       010177       010100
         374040            403700       073060       300700
         376010            603700       412214       224100
         010274            020100       615141       454300
         0                 0            141414       141400
         0                 0            0            0
         0                 0            0            0

         0                 0            204040       403700
         771014            224100       774040       404000
         770214            027700       770214       207700
         364141            413600       771111       110600
         364151            215600       771111       314600
         0                 0            0            0
         101010            101000       000041       221400
         101074            101000       001422       410000

         0                 0            761111       117600
         774545            453200       364141       412200
         774141            413600       774545       414100
         770505            010100       364151       513000
         771010            107700       004177       410000
         010300            010300       000060       600000
         030200            030200

start ps5
```

```
3/          jmp sbf             / ignore seq. break
            jmp a40
            jmp a1      / use test word for control, not iot 11 co


/ interesting and often changed constants

/symb loc   usual value (all instructions are executed,
            / and may be replaced by jda or jsp)

tno,  6,    law i 41            / number of torps + 1
tvl,  7,    sar 4s      / torpedo velocity
rlt,  10,   law i 20    / torpedo reload time
tlf,  11,   law i 140           / torpedo life
foo,  12,   -20000      / fuel supply
maa,  13,   10          / spaceship angular acceleration
sac,  14,   sar 4s      / spaceship acceleration
str,  15,   100         / star capture radius
me1,  16,   6000        / collision "radius"
me2,  17,   3000        / above/2
ddd,  20,   -0          / 0 to save space for ddt
the,  21,   sar 9s      / amount of torpedo space warpage
mhs,  22,   law i 10    / number of hyperspace shots
hd1,  23,   law i 40    / time in hyperspace before breakout
hd2,  24,   law i 100           / time in hyperspace breakout
hd3,  25,   law i 200           / time to recharge hyperfield generators
hr1,  26,   scl 9s      / scale on hyperspatial displacement
hr2,  27,   scl 4s      / scale on hyperspatially induced velocity
hur,  30,   40000       / hyperspatial uncertancy
ran,  31,   0           / random number
grv,  32,   sar 6s      / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. Low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,        jmp mg1     / normally iot 11 control
. 20/       / space
```

```
/ routine to flush sequence breakes, if they occur.

sbf,      tyi
          lio 2
          lac 0
          lsm
          jmp i 1

          define
xincr X,Y,INS
          lac Y
          INS s̅sn
          dac Y
          lac X
          INS s̅cn
          dac X
          term

          define
yincr X,Y,INS
          lac Y
          INS s̅cn
          dac Y
          lac X
          -INS+add+sub s̅sn
          dac X
          terminate

          define
dispatch
          add (. 3
          dap . 1
          jmp .
          term

          define
dispt A,Y,B
          repeat 6  B=B+B
          lio Y
          jda kcb
          xct db1
          term

          define
scale A,B,C
          lac A
          sar B
          dac C
          term
          define
diff V,S,SF
          add i V
          dac i V
          xct SF
          add i S
          dac i S
          term


          define
random
          lac ran
          rar 1s
          xor (355670
          add (355670
          dac ran
          term

          define
ranct S,SS,C
          random
          S
          SS
          sma
          cma
          dac C
          terminate
```

```
define
          varsft
          dzm x̅ys
          dac t̅1
          idx x̅ys
v2,       idx x̅ys
          lac t̅1
          scr 2s
          dac t̅1
          sza
          jmp v2+R
          scr 2s
          swap
          terminate
define
          undosft
          dac t1
          dio t̅2
          lac x̅ys
          add sft
          dap .+
          lac .
          dac .+6
          dac .+6
          xor (10000           / changescr to scl or scl to scr.
          dac x̅yt
          lac t̅1
          dio t̅2
          scr .
          scr .
          terminate
define
          integrate A,B
          cli
          lac i A
          scr 9s
          scr 1s
          div t̅1
          hlt
          cma+cli-opr
          xct x̅yt
          xct grv
          dac B
          terminate

sft,      lac .-1
          scr 7s
          scr 6s
          scr 5s
          scr 4s
          scr 3s
          scr 2s
          scr 1s
          scr
          scl 1s
```

```
/sine-cosine subroutine•Adams associates
/calling sequence= number in AC, jda sin or jdacos.
/argument is between ±2 pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = 2.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,        0
            dap csx
            lac (62210
            add cos
            dac sin
            jmp .+4

sin,        0
            dap csx
            lac sin
            spa
si1,        add (311040
            sub (62210
            sma
            jmp si2
            add (62210

si3,        ral 2s
            mul (242763
            dac sin
            mul sin
            dac cos
            mul (756103
            add (121312
            mul cos
            add (532511
            mul cos
            add (144417
            mul sin
            scl 3s
            dac cos
            xor sin
            sma
            jmp csx-1
            lac (377777
            lio sin
            spi
            cma
            jmp csx

            lac cos
csx,        jmp .

si2,        cma
            add (62210
            sma
            jmp si3
            add (62210
            spa
            jmp .+3
            sub (62210
            jmp si3

            sub (62210
            jmp si1
```

```
/integer square root
/input in ac, binary point to right of bit 17, jda sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,        0
            dap sqx
            law i 23
            dac sq1
            dzm sq2
            lio sqt
            dzm sqt

sq3,        isp sq1
            jmp .+3
            lac sq2
sqx,        jmp .

            lac sq2
            sal 1s
            dac sq2
            lac sqt
            rcl 2s
            sza i
            jmp sq3
            dac sqt
            lac sq2
            sal 1s
            add (1
            sub sqt
            sma+sza-skp
            jmp sq3
            spa
            cma
            dac sqt
            idx sq2
            jmp sq3

sq1,        0
sq2,        0
```

```
/outline compiler
/ac=where to compile to, call    jda oc
                                        /ot=address of outline table

define
           plinst A
           lac A
           dac i oc
           idx oc
           terminate

define
           comtab A, B
           plinst A
           jsp ocs
           lac B
           jmp oce
           terminate

ocs,       dap ocz                      /puts in swap
           dio i oc
           idx oc
ocz,       jmp .

oc,        0                            /outline compiler proper
           dap ocx
           lac i ocx
           dap ocg
           plinst (stf 5
           dap ocm
           idx ocx
ock,       plinst (lac s̅y1
           plinst (lio s̅y1
           clf 6
ocj,       setup o̅cc,6
ocg,       lio .                        /outline table
och,       cla
           rcl 3s
           dio o̅ci
           lio (swp                     swp=opr 60
           dispatch
           opr
           jmp oc1
oco,       jmp oc2
ocq,       jmp oc3
ocp,       jmp oc4
ocr,       jmp oc5
           jmp oc6
```

```
            plinst (szf 5          /7 code
            add (4
            dap ocn
            plinst ocn
            plinst (dac s̅x1
            plinst (dio s̅y1
            plinst (jmp sq6
            plinst (clf 5
            plinst (lac s̅cm
            plinst (cma
            plinst (dac s̅cm
            plinst (lac s̅sm
            plinst (cma
            plinst (dac s̅sm
            plinst (lac c̅sm
            plinst (lio s̅sd
            plinst (dac s̅sd
            plinst (dio c̅sm

            plinst (lac s̅sc
            plinst (lio c̅sn
            plinst (dac c̅sn
            plinst (dio s̅sc
            plinst ocm
ocx,        jmp .

ocm,        jmp .
ocn,        jmp .

oc1,        plinst (add s̅sn
            jsp ocs
            lac (sub s̅cn
oce,        dac i oc
            idx oc
            jsp ocs
            plinst (ioh
            lac (xct db2
ocd,        dac i oc
            idx oc
            lio o̅ci
            count o̅cc, och
            idx ocg
            jmp ocj

oc2,        comtab (add s̅cm, (add s̅sm
oc3,        comtab (add s̅sc, (sub c̅sm
oc4,        comtab (sub s̅cm, (sub s̅sm
oc5,        comtab (add c̅sn, (sub s̅sd
oc6,        szf 6
            jmp oc9
            stf 6
            plinst (dac s̅sa
            lac (dio s̅si
            jmp ocd
oc9,        clf 6
            plinst (lac s̅sa
            lac (lio s̅si
            jmp ocd
```

```
/display gravitational star

define
            starp
            add bx
            swap
            add by
            swap
            ioh
            xct db2
            terminate

blp,        dap blx                     /star
            szs 60
            jmp blx
            random
            rar 9s
            and (400700
            spa
            xor (377777
            dac bx
            lac ran
            ral 4s
            and (400700
            spa
            xor (377777
            dac by
            jsp bpt
            ioh
blx,        jmp .

bpt,        dap bpx
            random
            sar 9s
            sar 6s
            spa
            cma
            sal 3s
            add (bds
            dap bjm
            clf 6
bjl,        cla cli-opr
            szf 4
            jmp bjq
            sub ny1 1
            swp
            sub nx1 1
            jmp bjm-1
bjq,        sub ny1
            swp
            sub nx1
            xct db2
bjm,        jmp .
bds,        repeat 10, starp
            szf 6
bpx,        jmp .
            stf 6
            lac bx
            cma
            dac bx
```

```
          jmp bjl

/background display . 3/13/62, prs.

          define
dislis J, Q
          dap fx+R
          clf 5
          lac flo+R
          dap fpo+R
fs,       dap fin+R
          dap fyn+R
          idx fyn+R

fin,      lac          /lac Y
          sub fpr      /right margin
          sma
          sub (20000
          add (2000
frr,      spq
fou,      jmp fuu+R
fie,      sub (1000
          sal 8s
fyn,      lio          /lio Y
          jda kcb
          xct db1
          stf 5
fid,      idx fyn+R
          sad (lio Q+2
          jmp flp+R
          sad fpo+R
          jmp fx+R
          dap fin+R
          idx fyn+R
          jmp fin+R

fuu,      szf 5
fx,       jmp          /return
          idx flo+R
          idx flo+R
          sas (Q+2
          jmp fid+R
          law J
          dac flo+R
          jmp fid+R

flp,      lac (lio J
          sad fpo+R
          jmp fx+R
          dap fin+R
          law J+
          dap fyn+R
          jmp fin+R

fpo,      lio
flo,      J
          terminate
```

```
            define
background
            jsp bck
            termin

bck,        dap bcx
            szs 40
            jmp bcx
            jsp 1m
            jsp 2m
            idx bcc
            and (1
            sza
            jsp 3m
bc1,        law 3
            and bcc
            sza i
            jsp 4m
bc3,        isp bkc
            jmp bcy
            law i 10
            dac bkc
            law i 1
            add fpr
            spa
            add (20000
            dac fpr
bcy,        jsp 1m
bcx,        jmp

1m,         dislis 1j, 1q
2m,         dislis 2j, 2q
3m,         dislis 3j, 3q
4m,         dislis 4j, 4q

bcc,        0
bkc,        0
fpr,        10000
```

```
mul=mus
div=dis

start
```

```
spacewar 4.4  5/21/63  ddp  - pt 2

/main control routine for spaceships

nob=30                                  /total number of colliding objects

ml0,        setup mtc, 5000             /delay for loop
            init ml1, mtb               /loc of calc routines
            add (nob
            dap mx1                     / x
nx1=mtb nob
            add (nob
            dap my1                     / y
ny1=nx1 nob
            add (nob
            dap ma1                     / count for length of explosion or torp
na1=ny1 nob
            add (nob
            dap mb1                     / count of instructions taken by calc routine
nb1=na1 nob
            add (nob
            dac mdx                     / dx
ndx=nb1 nob
            add (nob
            dac mdy                     / dy
ndy=ndx nob
            add (nob
            dap mom                     /angular velocity
nom=ndy nob
            add (2
            dap mth                     / angle
nth=nom 2
            add (2
            dac mfu                     /fuel
nfu=nth 2
            add (2
            dac mtr                     / no torps remaining
ntr=nfu 2
            add (2
            dap mot                     / outline of spaceship
not=ntr 2
            add (2
            dap mco                     / old control word
nco=not 2
            add (2
            dac mh1
nh1=nco 2
            add (2
            dac mh2
nh2=nh1 2
            add (2
            dac mh3
nh3=nh2 2
            add (2
            dac mh4
nh4=nh3 2
nnn=nh4 2
```

```
4          szf 4
           jmp . 4
           law dj6
           stf 4
           jmp . 3
           law dj5
           clf 4
           dap . 1
           lac .
           dac db1
           idx .-2
           xct .-3
           dac db2

           law ss1
           xor mtb
           sza
           jmp mdn
           law ss2
           xor mtb 1
           sza
           jmp mdn
           law 1      / test if both ships out of torps
           add ntr
           spa
           jmp md1
           law 1
           add ntr 1
           spa i
           jmp mdn
md1,       xct tlf    / restart delay is 2X torpedo life
           sal 1s
           dac n̄td
           jmp ml1

mdn,       count n̄td,ml1
           stf 1
           stf 2
           law ss1
           xor mtb
           sza
           clf 1
           sza i
           idx 1sc
           law ss2
           xor mtb 1
           sza
           clf 2
           sza i
           idx 2sc
           clf 2
           jmp a
db1,       0
db2,       0
dj5,       dpy-i
           dpy-4000
dj6,       dpy-i 400
           dpy-4000 400
```

```
a1,         law mg2                / test word control
            dac cwg
            jmp a

a40,        law cwr    / here from start at 4
            dac cwg
            jmp a6

1sc,        0          /scores
2sc,        0

a,          lac gct
            sma
            jmp a5
            count gct, a5
            lac 1sc
            sas 2sc
            jmp a4
            lac fiu
            sad (jmp 4
            jmp a4
            law i1
            dac gct
a5,         lat
            and (40
            sza i
            jmp a2
a4,         jmp fi1
            lat
            and (40
            sza
            jmp a2
            dzm 1sc
            dzm 2sc
a6,         lat
            rar 6s
            and (37
            sza
            cma
            dac gct
a2,         clear mtb, nnn-1       / clear out all tables
            law ss1
            dac mtb
            law ss2
            dac mtb 1
            lac (200000
            dac nx1
            dac ny1
            cma
            dac nx1 1
            dac ny1 1
            lac (144420
            dac nth
```

```
          law nnn   / start of outline program
          dac not
          lio ddd
          spi i
          jmp a3
          jda oc              / compile outline
          ot1
a3,       dac not 1
          dap fi1
          jda oc
          ot2
          dap fi2
          xct tno
          dac ntr
          dac ntr 1
          lac foo
          dac nfu
          dac nfu+1
          law 2000
          dac nb1
          dac nb1 1
          xct mhs
          dac nh2
          dac nh2 1
          jmp m10
```

```
/ cotrol word get routines

mg1,      dap mg3
          cli
          iot 11
          rir 4s
mg3,      jmp .

mg2,      dap mg4
          lat
          swap
mg4,      jmp .

idl,      idx mth
          idx m̄fu
          idx m̄tr
          idx mco
          idx mot
          idx mom
          idx m̄h1
          idx m̄h2
          idx m̄h3
          idx m̄h4
ids,      idx mx1
          idx my1
          idx ma1
          idx mb1
          idx m̄dy
          idx m̄dx
ml1,      lac .               / 1st control word
          sza i               / zero if not active
          jmp mq1             / not active
          dap . 1
          jmp .
mb1,      lac .               / alter count of number of instructions
          add m̄tc
          dac m̄tc
mq1,      idx ml1
          sad (lac mtb 1
          jmp idl
          sas (lac mtb nob
          jmp ids
          background
          jsp blp             / display massive star
          count m̄tc, .        / use up rest of time of main loop
          jmp ml0             / repeat whole works
```

```
col,      dap cox
          law 1
          add ml1
          sad (lac mtb nob
          jmp cox-1
          dap ml2
          law 1
          add mx1
          dap mx2
          law 1
          add my1
          dap my2
          law 1
          add ma1
          dap ma2
          law 1
          add mb1
          dap mb2
ml2,      lac .                   / 2nd control word
          spq           / can it collide?
          jmp mq2                 / no
mx1,      lac .                   / calc if collision
mx2,      sub .                   / delta x
          spa                     / take abs val
          cma
          dac m̅t1
          sub me1                 / < EPSILON ?
          sma
          jmp mq2                 / no
my1,      lac .
my2,      sub .
          spa
          cma
          sub me1                 / < epsilon ?
          sma
          jmp mq2                 / no
          add m̅t1
          sub me2
          spa
          jmp cox
mq2,      idx mx2                 / end of comparison loop
          idx my2
          idx ma2
          idx mb2
          index ml2, (lac mtb nob, ml2
          idx cox
cox,      jmp .
```

```
/routine to set explosion

            law 20
            dac i mb1
            dac i mb2
sex,        lac (mex 400000       /EXPLODE
            dac i ml1             / replace calc routine with explosion
            dac i ml2
            lac i mb1             / duration of explosion
mb2,        add .
            cma
            sar 8s
            add (1
ma1,        dac .
ma2,        dac .

/ misc calculation routines

            / explosion

mex,        lac i m̄dx
            sar 3s
            add i mx1
            dac i mx1
            lac i m̄dy
            sar 3s
            add i my1
            dac i my1
            law mst
            dap msh
            lac i mb1             / time involved
            cma cli-opr
            sar 3s
            dac m̄xc
            sub (140
            sma
            idx msh
mz1,        lac ran
            and (777
            ior (scl
            dac mi1
            random
            scr 9s
            sir 9s
msh,        xct .
mi1,        hlt
            add i my1
            swap
            add i mx1
            jda kcb
            xct db1
            count m̄xc, mz1
            count i ma´, mb1
            dzm i ml1
            jmp mb1

mst,        scr 1s
            scr 3s
```

```
/ torpedo calc routine

tcr,        jsp col
            jmp sex-3
            count i ma1, tc1
            lac (mex 400000
            dac i ml1
            law i 2
            dac i ma1
            law 20
            dac i mb1
            jmp mb1

tc1,        lac i mx1
            sar 9s
            xct the
            add i m̄dy
            dac i m̄dy
            sar 3s
            add i my1
            dac i my1
            sar 9s
            xct the
            add i m̄dx
            dac i m̄dx
            sar 3s
            add i mx1
            dac i mx1
            dispt i, i my1, 1
            jmp mb1

/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,        count i ma1, mb1
            law hp3                 / next step
            dac i ml1
            law 7
            dac i mb1
            random
            scr 9s
            sir 9s
            xct hr1
            add i mx1
            dac i mx1
            swap
            add i my1
            dac i my1
            dzm i mdx
            dzm i mdy
            xct hd2
            dac i ma1
            jmp mb1
```

```
/ this routine handles a ship breaking out of
/ hyperspace.

hp3,        jsp col
            jmp sex
            count i ma1,hp6
            law 2000
            dac i mb1
            lac i mh4
            add hur
            dac i mh4
            random
            ior (400000
            add i mh4
            sma
            jmp po1
            lac i mh1
            dac i ml1
            lac ran
            scr 9s
            sir 9s
            xct hr2
            dac i mdy
            dio i mdx
            setup hpt,3
            lac ran
            sar 6s
            dac i mom
            lac ran
            dac i mth
hp4,        lac i mth
            sma
            sub (311040
            spa
            add (311040
            dac i mth
            count hpt,hp4
            count i mh2,hp7
            dzm i mh2
hp7,        xct hd3
            dac i mh3
hp6,        lac i mx1
            dispt i  i my1, 2
            jmp mb1


kcb,        0                       /relocate for center display
            dap kc1
            lac kcb
            szf 4
            jmp . 6
            sub nx1 1
            swap
            sub ny1 1
            swap
            jmp kc1
            sub nx1
            swap
            sub ny1
            swap
kc1,        jmp .
```

```
/ spaceship calc
ss1,        jsp i c̅wg
            dio s̅cw
            jmp sr0

ss2,        jsp i cwg
            rir 4s
            dio s̅cw

sr0,
sc1,        clf 6
            jsp col
            jmp sex
            lio s̅cw
            clf 6 cla-opr          /update angle
            spi
            add maa
            ril 1s
            spi
            sub maa
mom,        add .
            dac i mom
            szs 10
            jmp . 3
            dzm i mom
            ral 7s
            ril 1s
            spi
            stf 6
            lio i m̅fu
            spi i
            clf 6

mth,        add .
            sma
            sub (311040
            spa
            add (311040
            dac i mth
            jda sin
            dac s̅n
            dzm b̅x
            dzm b̅y
            szs 60
            jmp bsg
            lac i mx1
            dac t̅1
            mul t̅1
            scr 1s
            dac a̅cx
            cla
            scr 2s
            dio l̅ox
            lac i my1
            dac t̅1
            mul t̅1
            scr 1s
            dac a̅cy
```

```
        cla
        scr 2s
        swap
        add i̅ox
        swap
        scl 2s
        add a̅cx
        add a̅cy
        sub str
        sma i sza-skp
        jmp pof
        add str
        varsft
        dac t̅1
        jda sqt
        mul t̅1
        undosft
        scr 9s
        scr 8s
        sza
        jmp bsg
        scr 1s
        dio t̅1
        integrate mx1, b̅x
        integrate my1, b̅y
bsg,    lac i mth
        jda cos
        dac c̅s
        sar 9s
        xct sac
        szf i 6
        cla
        add b̅y
        diff m̅dy, my1, (sar 3s
        lac s̅n
        sar 9s
        xct sac
        cma
        szf i 6
        cla
        add b̅x
        diff m̅dx, mx1, (sar 3s
        scale s̅n, 5s, s̅sn
        scale c̅s, 5s, s̅cn
        lac i mx1
        szf 4
        sub nx1
        szf i 4
        sub nx1 1
        sub s̅sn
        dac s̅x1
        sub s̅sn
        dac s̅tx
```

```
             lac i my1
             szf 4
             sub ny1
             szf i 4
             sub ny1 1
             add s̅cn
             dac s̅y1
             add s̅cn
             dac s̅ty
             scale s̅n, 9s, ssn
             scale c̅s, 9s, scn
             dac s̅cm
             lac s̅sn
             dac s̅sm
             add s̅cn
             dac s̅sc
             dac s̅sd
             lac s̅sn
             sub s̅cn
             dac c̅sn
             cma
             dac c̅sm
             cla cli-opr
             jda kcb
             xct db2
mot,sp5,     jmp i .
sq6,         ioh
             lio s̅cw
             ril 2s
             spi i                  / not blasting
             jmp sq9                / no tail
             ranct sar 9s, sar 4s, s̅rc
             scale s̅n, 8s, s̅sn
             scale c̅s, 8s, s̅cn
sq7,         count i mfu, st2
             dzm i mfu
             jmp sq9
```

```
st2,      yincr s̅x1, s̅y1, sub
          lio s̅y1
          xct db1̲
          count s̅rc,sq7
sq9,      count i ma1, sr5        / check if torp tube reloaded
          dzm i ma1               / prevent count around
mco,      lac .                   / previous control word
          cma
          szs i 30
          clc
          and s̅cw   / present control word
          ral 3s                  / torpedo bit to bit 0
          sma
          jmp sr5                 / no launch
          count i̲ m̅tr, st1        / check if torpedos exhausted
          dzm i mtr                          /prevent count around
          jmp sr5
st1,      init sr1, mtb nob-1                /search for unused object
sr1,      lac .
          sza i                   / 0 if unused
          jmp sr2
          law i 1
          add sr1
          dap sr1
          sas (lac mtb-1
          jmp sr1
          jmp sr5                 / no space for new objects

sr2,      lac (tcr                / set up torpedo calc
          dac i sr1
          law nob
          add sr1
          dap ss3
          lio s̅tx
          swp
          szf 4
          add nx1
          szf i 4
          add nx1 1
          swp
ss3,      dio .
          add (nob
          dap ss4
          lio s̅ty
          swp
          szf 4
          add ny1
          szf i 4
          add ny1 1
          swp
ss4,      dio .
```

```
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac s̅n
        xct tv1
        cma
        add i m̅dx
sr3,    dac .
        lac c̅s
        xct tv1
        add i m̅dy
sr4,    dac .
        xct rlt
        dac i ma1           / permit torp tubes to cool
        xct tlf   / life of torpedo
sr6,    dac .
        lac (lac mtb nob-1
        sub sr1
        sal 3s
        add (30
sr7,    dap .               / length of torp calc.
sr5,    lac s̅cw
        dac i mco
        count i mh3, mb1
        dzm i m̅h3
        lac i m̅h2
        sza i
        jmp mb1
        lac s̅cw
        and (600000
        xor (600000
        sza
        jmp mb1
        lac i ml1
        dac i m̅h1
        lac (hp1 400000
        dac i  ml1
        xct hd1
        dac i ma1
        law 2
        dac i mb1
        jmp mb1
```

```
/ here to handle spaceships dragged into star


/ spaceship in star

pof,        dzm i m̅dx
            dzm i m̅dy
            szs 50
            jmp po1
            lac (377777
            dac i mx1
            dac i my1
            lac i mb1
            dac s̅sn
            count s̅sn, .
            jmp mb1

po1,        lac (mex 400000       / now go bang
            dac i ml1
            law i 10
            dac i ma1
            jmp mb1

/ outlines of spaceships

ot1,        111131
            111111
            111111
            111163
            311111
            146111
            111114
            700000
. 5/

ot2,        013113
            113111
            116313
            131111
            161151
            111633
            365114
            700000
. 5/


            variables
            constants


.-60/
p,          . 100/                / space for patches
```

```
/display score routine

fss,        0           /set size of spaceship
            dap fs1
            lac fss
            dac s̅cm
            dac ss̅c
            dac s̅sd
            dac s̅cn
            dac cs̅m
            cma
            dac c̅sn
            dzm s̅sn
            dzm s̅sm
fs1,        jmp .

fi1,        law .       /set return of compiled outline
            sub c21
            dac t6
fi2,        law .
            sub c21
            dac t7
fis,        lac c23
            dac t4
            szf 3
            lio 2sc     /get score
            szf i 3
            lio 1sc
            scl 1s
            cla
            div c12
            hlt
            sza
            jmp fx1
fkr,        dio t3
            law 400
            jda fss
            law fys
            dap frt
flt,        idx t3
            cma
            dac t3
            law fus
            dap i t6
            dap i t7
fus,        lac c20
            szf 3
            cma
            dac sy1
            lac t4
            add c30
            dac t4
            dac sx1
```

```
fds,        szf 3      /display spaceship
            law not
            szf i 3
            law not 1
            dap fug
            idx t5
            ral 9s
            cli
            xct db2
            isp t3
fug,        jmp i .
frt,        jmp .

fys,        law 4000
            jda fss
            law fub
            dap i t6
            dap i t7
            lac c26
            dac sx1
            lac c20
            szf i 3
            cma
            add c30
            dac sy1
            law i 2
            dac t3
            jmp fds
fub,        szf 3
            jmp . 3
            stf 3
            jmp . 2
            clf 3
            cli
            iot 11
            dio t1
            law 21
            xor t1
            sza i
            jmp fik
            law 42
            xor t1
            sza
            jmp fkg
            law a4+
            jmp fwt-1
fik,        law 4
            dap fiu
fwt,        add .
            dac t1
            isp t1
            jmp .-1
fiu,        jmp .
```

```
fx1,        dio t̄1
            dac t3
            law fx2
            dap frt
            law 1100
            jda fss
            jmp flt
fx2,        lio t̄1
            jmp fkr

fkg,        szf 3
            jmp fis
            szf 4
            jmp . 4
            law dj6
            stf 4
            jmp . 3
            law dj5
            clf 4
            dap . 1
            lac .
            dac db1
            idx .-2
            xct .-3
            dac db2
            jmp fis

c12,        12
c20,        200000
c21,        21
c23,        -200000-30000
c26,        -260000
c30,        30000
t3,         0
t4,         0
t5,         0
t6,         0
t7,         0

mtb,                    / table of objects and their properties

start 4
```

```
spacewar 4.4  5/17/63  ddp  : pt 1 - pass 1
spacewar 4.4  5/21/63  ddp  : pt 2 - pass 1
stars by prs  for s/w 2b - pass 1
foo
nx1=mtb nob
ny1=nx1 nob
start
foo - pass 1
spacewar 4.4  5/17/63  ddp  : pt 1 - pass 2
spacewar 4.4  5/21/63  ddp  : pt 2 - pass 2
usw      1362      a+13      count     i1
stars by prs  for s/w 2b - pass 2
spacewar 4.4 syms   5/23/63   jcm

Constants area, inclusive
from     to
2736     3063
```

1j	6077
1m	706
1q	6117
1sc	1345
2j	6121
2m	764
2q	6141
2sc	1346
3j	6143
3m	1042
3q	6403
4j	6405
4m	1120
4q	7747
a	1347
a1	1337
a2	1405
a3	1436
a4	1370
a40	1342
a5	1364
a6	1377
acx	2727
acy	2731
bc1	667
bc3	673
bcc	1176
bck	656
bcx	705
bcy	704
bds	544
bjl	530
bjm	543
bjq	537
bkc	1177
blp	464
blx	511
bpt	512
bpx	645
bsg	2275
bx	2704
by	2705
c12	3407
c21	3411
c23	3412
c26	3413
c20	3410
c30	3414
col	1534
cos	100
cox	1614
cs	2732
csm	2676
csn	2701

```
csx       146
cwg       2720
cwr       40
db1       1331
db2       1332
ddd       20
dj5       1333
dj6       1335
fds       3272
fi1       3225
fi2       3230
fid       24
fie       16
fik       3347
fin       7
fis       3233
fiu       3355
fkg       3367
fkr       3247
flo       55
flp       45
flt       3254
foo       12
fou       15
fpo       54
fpr       1200
frr       14
frt       3305
fs        4
fs1       3224
fss       3210
fub       3325
fug       3304
fus       3262
fuu       34
fwt       3351
fx        35
fx1       3356
fx2       3365
fyn       20
fys       3306
gct       2721
grv       32
hd1       23
hd2       24
hd3       25
hp1       1744
hp3       1775
hp4       2036
hp6       2053
hp7       2051
hpt       2724
hr1       26
hr2       27
```

hur	30
idl	1472
ids	1504
iox	2730
kc1	2102
kcb	2060
ma1	1630
ma2	1631
maa	13
mb1	1517
mb2	1624
mco	2451
md1	1303
mdn	1307
mdx	2707
mdy	2710
me1	16
me2	17
mex	1632
mfu	2711
mg1	1460
mg2	1465
mg3	1464
mg4	1471
mh1	2713
mh2	2714
mh3	2715
mh4	2716
mhs	2[illegible]
mi1	1667
ml1	1512
ml2	1556
ml0	1201
mom	2123
mot	2402
mq1	1522
mq2	1604
msh	1666
mst	1704
mt1	2722
mtb	3422
mtc	2706
mth	2137
mtr	2712
mx1	1561
mx2	1562
mxc	2723
my1	1571
my2	1572
mz1	1653
na1	3532
nb1	3562
nco	3704
ndx	3612

```
ndy        3642
nfu        3676
nh1        3706
nh2        3710
nh3        3712
nh4        3714
nnn        3716
nob        30
nom        3672
not        3702
ntd        2717
nth        3674
ntr        3700
nx1        3452
ny1        3502
oc         226
oc1        373
oc2        416
oc3        424
oc4        432
oc5        440
oc6        446
oc9        456
occ        2672
ocd        407
oce        400
ocg        250
och        251
oci        2673
ocj        246
ock        237
ocm        371
ocn        372
oco        262
ocp        264
ocq        263
ocr        265
ocs        222
ocx        370
ocz        225
ot1        2630
ot2        2645
p          3110
po1        2623
pof        2607
ran        31
rlt        10
sac        14
sbf        61
sc1        2111
scm        2674
scn        2663
scw        2725
sex        1620
```

```
sft         66
si1         112
si2         147
si3         117
sin         106
sn          2726
sp5         2402
sq1         220
sq2         221
sq3         171
sq6         2403
sq7         2430
sq9         2446
sqt         162
sqx         174
sr1         2467
sr2         2500
sr3         2543
sr4         2547
sr5         2561
sr6         2553
sr7         2560
src         2735
sr0         2111
ss1         2103
ss2         2106
ss3         2514
ss4         2526
ssa         2702
ssc         2700
ssd         2677
ssi         2703
ssm         2675
ssn         2662
st1         2465
st2         2434
str         15
stx         2733
sty         2734
sx1         2670
sy1         2671
t1          2665
t2          2666
t3          3415
t4          3416
t5          3417
t6          3420
t7          3421
tc1         1721
tcr         1706
the         21
tlf         11
tno         6
tvl         7
```

v2	3
xys	2664
xyt	2667

```
spacewar 4.3  5/17/63  ddp  .  pt 1

3/          jmp sbf             / ignore seq. break
            jmp a40
            jmp a1     / use test word for control, not iot 11 co


/ interesting and often changed constants

/symb loc   usual value (all instructions are executed,
          / and may be replaced by jda or jsp)

tno,  6,  law i 41              / number of torps + 1
tvl,  7,  sar 4s     / torpedo velocity
rlt, 10,  law i 20   / torpedo reload time
tlf, 11,  law i 140             / torpedo life
foo, 12,  -20000     / fuel supply
maa, 13,  10         / spaceship angular acceleration
sac, 14,  sar 4s     / spaceship acceleration
str, 15,  100        / star capture radius
me1, 16,  6000       / collision "radius"
me2, 17,  3000       / above/2
ddd, 20,  -0         / 0 to save space for ddt
the, 21,  sar 9s     / amount of torpedo space warpage
mhs, 22,  law i 10   / number of hyperspace shots
hd1, 23,  law i 40   / time in hyperspace before breakout
hd2, 24,  law i 100             / time in hyperspace breakout
hd3, 25,  law i 200             / time to recharge hyperfield generators
hr1, 26,  scl 9s     / scale on hyperspatial displacement
hr2, 27,  scl 4s     / scale on hyperspatially induced velocity
hur, 30,  40000      / hyperspatial uncertancy
ran, 31,  0          / random number
grv, 32,  sar 6s     / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. Low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,      jmp mg1    / normally iot 11 control
. 20/     / space
```

```
/ routine to flush sequence breakes, if they occur.

sbf,        tyi
            lio 2
            lac 0
            lsm
            jmp i 1

            define
xincr X,Y,INS
            lac Y
            INS s̄sn
            dac Y
            lac X
            INS s̄cn
            dac X
            term

            define
yincr X,Y,INS
            lac Y
            INS s̄cn
            dac Y
            lac X
            -INS+add+sub s̄sn
            dac X
            terminate

            define
dispatch
            add (. 3
            dap . 1
            jmp .
            term

            define
dispt A,Y,B
            repeat 6  B=B+B
            lio Y
            szs 20
            jda kcb
            dpy-A+B
            term

            define
scale A,B,C
            lac A
            sar B
            dac C
            term
```

```
        define
diff V,S,SF
        add i V
        dac i V
        xct SF
        add i S
        dac i S
        term


        define
random
        lac ran
        rar 1s
        xor (355670
        add (355670
        dac ran
        term

        define
ranct S,SS,C
        random
        S
        SS
        sma
        cma
        dac C
        terminate
```

```
define
          varsft
          dzm xys
          dac t1
          idx xys
v2,       idx xys
          lac t1
          scr 2s
          dac t1
          sza
          jmp v2+R
          scr 2s
          swap
          terminate
define
          undosft
          dac t1
          dio t2
          lac xys
          add sft
          dap .+1
          lac .
          dac .+6
          dac .+6
          xor (10000          / change scr to scl or scl to scr.
          dac xyt
          lac t1
          dio t2
          scr .
          scr .
          terminate
define
          integrate A,B
          cli
          lac i A
          scr 9s
          scr 1s
          div t1
          hlt
          cma+cli-opr
          xct xyt
          xct grv
          dac B
          terminate

sft,      lac .-1
          scr 7s
          scr 6s
          scr 5s
          scr 4s
          scr 3s
          scr 2s
          scr 1s
          scr
          scl 1s
```

```
/sine-cosine subroutine•Adams associates
/calling sequence= number in AC, jda sin or jdacos.
/argument is between ±2 pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = 2.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,        0
            dap csx
            lac (62210
            add cos
            dac sin
            jmp .+4

sin,        0
            dap csx
            lac sin
            spa
si1,        add (311040
            sub (62210
            sma
            jmp si2
            add (62210

si3,        ral 2s
            mul (242763
            dac sin
            mul sin
            dac cos
            mul (756103
            add (121312
            mul cos
            add (532511
            mul cos
            add (144417
            mul sin
            scl 3s
            dac cos
            xor sin
            sma
            jmp csx-1
            lac (377777
            lio sin
            spi
            cma
            jmp csx

            lac cos
csx,        jmp .

si2,        cma
            add (62210
            sma
            jmp si3
            add (62210
            spa
            jmp .+3
            sub (62210
            jmp si3

            sub (62210
/integer square root
/input in ac, binary point to right of bit 17, jda sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,        0
            dap sqx
            law i 23
            dac sq1
            dzm sq2
            lio sqt
            dzm sqt

sq3,        isp sq1
            jmp .+3
            lac sq2
sqx,        jmp .

            lac sq2
            sal 1s
            dac sq2
            lac sqt
            rcl 2s
            sza i
            jmp sq3
            dac sqt
            lac sq2
            sal 1s
            add (1
            sub sqt
            sma+sza-skp
            jmp sq3
            spa
            cma
            dac sqt
            idx sq2
            jmp sq3

sq1,        0
sq2,        0
```

```
/outline compiler
/ac=where to compile to, call    jda oc
                                /ot=address of outline table

define
          plinst A
          lac A
          dac i oc
          idx oc
          terminate

define
          comtab A, B
          plinst A
          jsp ocs
          lac B
          jmp oce
          terminate

ocs,      dap ocz                 /puts in swap
          dio i oc
          idx oc
          dio i oc
          idx oc
ocz,      jmp .

oc,       0                       /outline compiler proper
          dap ocx
          lac i ocx
          dap ocg
          plinst (stf 5
          dap ocm
          idx ocx
ock,      plinst (lac s̅x1
          plinst (lio s̅y1
          clf 6
ocj,      setup o̅cc,6
ocg,      lio .                   /outline table
och,      cla
          rcl 3s
          dio o̅ci
          lio (rcl 9s
          dispatch
          opr
          jmp oc1
oco,      jmp oc2
ocq,      jmp oc3
ocp,      jmp oc4
ocr,      jmp oc5
          jmp oc6
          plinst (szf 5        /7 code
          add (4
          dap ocn
          plinst ocn
          plinst (dac s̄x1
          plinst (dio s̄y1
          plinst (jmp s̄q6
          plinst (clf 5
          plinst (lac s̄cm
          plinst (cma
          plinst (dac s̄cm
          plinst (lac s̄sm
          plinst (cma
          plinst (dac s̄sm
          plinst (lac c̄sm
          plinst (lio s̄sd
          plinst (dac s̄sd
          plinst (dio c̄sm

          plinst (lac s̄sc
          plinst (lio c̄sn
          plinst (dac c̄sn
          plinst (dio s̄sc
          plinst ocm
ocx,      jmp .

ocm,      jmp .
ocn,      jmp .

oc1,      plinst (add s̄sn
          jsp ocs
          lac (sub s̄cn
oce,      dac i oc
          idx oc
          jsp ocs
          plinst (ioh
          lac (dpy-4000
ocd,      dac i oc
          idx oc
          lio ōci
          count ōcc, och
          idx ocg
          jmp ocj

oc2,      comtab (add s̄cm, (add s̄sm
oc3,      comtab (add s̄sc, (sub c̄sm
oc4,      comtab (sub s̄cm, (sub s̄sm
oc5,      comtab (add c̄sn, (sub s̄sd
oc6,      szf 6
          jmp oc9
          stf 6
          plinst (dac s̄sa
          lac (dio s̄si
          jmp ocd
oc9.      clf 6
          plinst (lac s̄sa
          lac (lio s̄si
          jmp ocd
```

```
/display gravitational star

define
          starp
          add b̄x
          swap
          add b̄y
          swap
          ioh
          dpy-4000
          terminate

blp,      dap blx                /star
          szs 60
          jmp blx
          random
          rar 9s
          and (400700
          spa
          xor (377777
          dac b̄x
          lac ran
          ral 4s
          and (400700
          spa
          xor (377777
          dac b̄y
          jsp bpt
          ioh
blx,      jmp .

bpt,      dap bpx
          random
          sar 9s
          sar 6s
          spa
          cma
          sal 3s
          add (bds
          dap bjm
          cla cli clf 6-opr-opr
          szf i 20
          jmp bjm-1
          sub ny1
          swap
          sub nx1
          dpy-4000
bjm,      jmp .
bds,      repeat 10, starp
          szf 6
bpx,      jmp .
          stf 6
          cma
          swap
          cma
          swap
          jmp bjm
```

```
/background display . 3/13/62, prs.

              define
dislis J,     0
              dap fx+R
              clf 5
              lac flo+R
              dap fpo+R
fs,           dap fin+R
              dap fyn+R
              idx fyn+R

fin,          lac           /lac X
              sub fpr       /right margin
              sma
              sub (20000
              add (2000
frr,          spc
fou,          jmp fuu+R
fie,          sub (1000
              sal 8s
fyn,          lio           /lio Y
              szs 20
              jda kcb
              dpy-i
              stf 5
fid,          idx fyn+R
              sad (lio Q+2
              jmp flp+R
              sad fpo+R
              jmp fx+R
              dap fin+R
              idx fyn+R
              jmp fin+R

fuu,          szf 5
fx,           jmp           /return
              idx flo+R
              idx flo+R
              sas (Q+2
              jmp fid+R
              law J
              dac flo+R
              jmp fid+R

flp,          lac (lio J
              sad fpo+R
              jmp fx+R
              dap fin+R
              law J+1
              dap fyn+R
              jmp fin+R

fpo,          lio
flo,          J
              terminate
```

```
            define
background
            jsp bck
            termin

bck,        dap bcx
            szs 40
            jmp bcx
            jsp 1m
            jsp 2m
            idx bcc
            and (1
            sza
            jsp 3m
bc1,        law 3
            and bcc
            sza i
            jsp 4m
bc3,        isp bkc
            jmp bcy
            law i 10
            dac bkc
            law i 1
            add fpr
            spa
            add (20000
            dac fpr
bcy,        jsp 1m
bcx,        jmp

1m,         dislis 1j, 1q
2m,         dislis 2j, 2q
3m,         dislis 3j, 3q
4m,         dislis 4j, 4q

bcc,        0
bkc,        0
fpr,        10000
```

```
mul=mus
div=dis


start
```

```
spacewar 4.3  5/17/63   ddp  . pt 2

/main control routine for spaceships

nob=30                         /total number of colliding objects

ml0,        setup m̅tc, 5000    /delay for loop
            init ml1, mtb      /loc of calc routines
            add (nob
            dap mx1            / x
nx1=mtb nob
            add (nob
            dap my1            / y
ny1=nx1 nob
            add (nob
            dap ma1            / count for length of explosion or torp
na1=ny1 nob
            add (nob
            dap mb1            / count of instructions taken by calc routine
nb1=na1 nob
            add (nob
            dac m̅dx            / dx
ndx=nb1 nob
            add (nob
            dac m̅dy            / dy
ndy=ndx nob
            add (nob
            dap mom            /angular velocity
nom=ndy nob
            add (2
            dap mth            / angle
nth=nom 2
            add (2
            dac m̅fu            /fuel
nfu=nth 2
            add (2
            dac m̅tr            / no torps remaining
ntr=nfu 2
            add (2
            dap mot            / outline of spaceship
not=ntr 2
            add (2
            dap mco            / old control word
nco=not 2
            add (2
            dac m̅h1
nh1=nco 2
            add (2
            dac m̅h2
nh2=nh1 2
            add (2
            dac m̅h3
nh3=nh2 2
            add (2
            dac m̅h4
nh4=nh3 2
nnn=nh4 2
```

```
        law ss1
        xor mtb
        sza
        jmp mdn
        law ss2
        xor mtb 1
        sza
        jmp mdn
        law 1       / test if both ships out of torps
        add ntr
        spa
        jmp md1
        law 1
        add ntr 1
        spa i
        jmp mdn
md1,    xct tlf     / restart delay is 2X torpedo life
        sal 1s
        dac n̄td
        jmp ml1

mdn,    count n̄td,ml1
        stf 1
        stf 2
        law ss1
        xor mtb
        sza
        clf 1
        sza i
        idx 1sc
        law ss2
        xor mtb 1
        sza
        clf 2
        sza i
        idx 2sc
        clf 2
        jmp a
```

```
a1,         law mg2               / test word control
            dac cwg
            jmp a

a40,        law cwr     / here from start at 4
            dac cwg
            jmp a6

1sc,        0          /scores
2sc,        0

a,          dzm 8j1
            dzm 8j2
            lac gct
            sma
            jmp a5
            count gct, a5
            lac 1sc
            sas 2sc
            jmp a4
            law i 1
            dac gct
a5,         lat
            and (40
            sza i
            jmp a2
a4,         jmp fi1
            lat
            and (40
            sza
            jmp a2
            dzm 1sc
            dzm 2sc
a6,         lat
            rar 6s
            and (37
            sza
            cma
            dac gct
a2,         clear mtb, nnn-1    / clear out all tables
            law ss1
            dac mtb
            law ss2
            dac mtb 1
            lac (200000
            dac nx1
            dac ny1
            cma
            dac nx1 1
            dac ny1 1
            lac (144420
            dac nth
```

```
                law nnn         / start of outline program
                dac not
                lio ddd
                spi i
                jmp a3
                jda oc          / compile outline
                ot1
a3,             dac not 1
                dap fi1
                jda oc
                ot2
                dap fi2
                xct tno
                dac ntr
                dac ntr 1
                lac foo
                dac nfu
                dac nfu+1
                law 2000
                dac nb1
                dac nb1 1
                xct mhs
                dac nh2
                dac nh2 1
                jmp ml0
```

```
/ control word get routines

mg1,        dap mg3
            iot 11
            jsp 8a
8j1,        0
            dac t1
            iot 111
            jsp 8a
8j2,        0
            lio t1
            ril 4s
            rcr 4s
mg3,        jmp .

mg2,        dap mg4
            lat
            swap
mg4,        jmp .

idl,        idx mth
            idx mfu
            idx mtr
            idx mco
            idx mot
            idx mom
            idx mh1
            idx mh2
            idx mh3
            idx mh4
ids,        idx mx1
            idx my1
            idx ma1
            idx mb1
            idx mdy
            idx mdx
ml1,        lac .                   / 1st control word
            sza i                   / zero if not active
            jmp mq1                 / not active
            dap . 1
            jmp .
mb1,        lac .                   / alter count of number of instructions
            add mtc
            dac mtc
mq1,        idx ml1
            sad (lac mtb 1
            jmp idl
            sas (lac mtb nob
            jmp ids
            background
            jsp blp                 / display massive star
            count mtc, .            / use up rest of time of main loop
            jmp ml0                 / repeat whole works
```

```
8a,         dap 8ay
            dap 8ax
            idx 8ax
            clf 7
            spi
            stf 5
            szf i 5
            stf 6
            ril 1
            spi
            jmp 8ao

8ay,        lac
            rir 8s
            spi
            cla
            rir 1s
            spi
            law 2
            dac i 8ay

8ad,        rir 8s
            spi
            jmp 8aq
            rir 5s
            spi
            ior (14
            rir 1s
            spi
            ior (1
            jmp 8aa

8ao         cla
            rir 9s
            spi
            law 2
            jmp 8ad

8aq,        rir 5s
            spi
            ior (1
            rir 1s
            spi
            ior (14
8aa,        rir 1s
            spi 5
            ior (4
            spi 6
            ior (10
            rir 1s
            spi 5
            ior (10
            spi 6
            ior (4
8ax,        jmp
```

```
col,      dap cox
          law 1
          add ml1
          sad (lac mtb nob
          jmp cox-1
          dap ml2
          law 1
          add mx1
          dap mx2
          law 1
          add my1
          dap my2
          law 1
          add ma1
          dap ma2
          law 1
          add mb1
          dap mb2
ml2,      lac .                / 2nd control word
          spq       / can it collide?
          jmp mq2              / no
mx1,      lac .                / calc if collision
mx2,      sub .                / delta x
          spa                  / take abs val
          cma
          dac m̅t1
          sub me1              / < EPSILON ?
          sma
          jmp mq2              / no
my1,      lac .
my2,      sub .
          spa
          cma
          sub me1              / < epsilon ?
          sma
          jmp mq2              / no
          add m̅t1
          sub me2
          spa
          jmp cox
mq2,      idx mx2              / end of comparison loop
          idx my2
          idx ma2
          idx mb2
          index ml2, (lac mtb nob, ml2
          idx cox
cox,      jmp .
```

```
/routine to set explosion

          law 20
          dac i mb1
          dac i mb2
sex,      lac (mex 400000      /EXPLODE
          dac i ml1            / replace calc routine with explosion
          dac i ml2
          lac i mb1            / duration of explosion
mb2,      add .
          cma
          sar 8s
          add (1
ma1,      dac .
ma2,      dac .

/ misc calculation routines

          / explosion

mex,      lac i m̄dx
          sar 3s
          add i mx1
          dac i mx1
          lac i m̄dy
          sar 3s
          add i my1
          dac i my1
          law mst
          dap msh
          lac i mb1            / time involved
          cma cli-opr
          sar 3s
          dac m̄xc
          sub (140
          sma
          idx msh
mz1,      lac ran
          and (777
          ior (scl
          dac mi1
          random
          scr 9s
          sir 9s
msh,      xct .
mi1,      hlt
          add i my1
          swap
          add i mx1
          szs 20
          jda kcb
          dpy-i 300
          count m̄xc, mz1
          count i ma1, mb1
          dzm i ml1
          jmp mb1

mst,      scr 1s
          scr 3s
```

```
/ torpedo calc routine

tcr,        jsp col
            jmp sex-3
            count i ma1, tc1
            lac (mex 400000
            dac i ml1
            law i 2
            dac i ma1
            law 20
            dac i mb1
            jmp mb1

tc1,        lac i mx1
            sar 9s
            xct the
            add i m̄dy
            dac i m̄dy
            sar 3s
            add i my1
            dac i my1
            sar 9s
            xct the
            add i m̄dx
            dac i m̄dx
            sar 3s
            add i mx1
            dac i mx1
            dispt i, i my1, 1
            jmp mb1

/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,        count i ma1, mb1
            law hp3             / next step
            dac i ml1
            law 7
            dac i mb1
            random
            scr 9s
            sir 9s
            xct hr1
            add i mx1
            dac i mx1
            swap
            add i my1
            dac i my1
            dzm i mdx
            dzm i mdy
            xct hd2
            dac i ma1
            jmp mb1
```

```
/ this routine handles a ship breaking out of
/ hyperspace.

hp3,        jsp col
            jmp sex
            count i ma1,hp6
            law 2000
            dac i mb1
            lac i m̅h4
            add hur
            dac i m̅h4
            random
            ior (400000
            add i m̅h4
            sma
            jmp po1
            lac i m̅h1
            dac i ml1
            lac ran
            scr 9s
            sir 9s
            xct hr2
            dac i mdy
            dio i mdx
            setup h̅pt,3
            lac ran
            sar 6s
            dac i mom
            lac ran
            dac i mth
hp4,        lac i mth
            sma
            sub (311040
            spa
            add (311040
            dac i mth
            count h̅pt,hp4
            count i m̅h2,hp7
            dzm i m̅h2
hp7,        xct hd3
            dac i m̅h3
hp6,        lac i mx1
            dispt i, i my1, 2
            jmp mb1


kcb,        0                       /relocate for center display
            dap kc1
            swap
            sub ny1
            swap
            lac kcb
            sub nx1
kc1,        jmp .
```

```
/ spaceship calc
ss1,        jsp i c̄wg
            dio s̄cw
            jmp sr0

ss2,        jsp i cwg
            rir 4s
            dio s̄cw

sr0,
sc1,        clf 6
            jsp col
            jmp sex
            lio s̄cw
            clf 6 cla-opr          /update angle
            spi
            add maa
            ril 1s
            spi
            sub maa
mom,        add .
            dac i mom
            szs 10
            jmp . 3
            dzm i mom
            ral 7s
            ril 1s
            spi
            stf 6
            lio i m̄fu
            spi i
            clf 6

mth,        add .
            sma
            sub (311040
            spa
            add (311040
            dac i mth
            jda sin
            dac s̄n
            dzm b̄x
            dzm b̄y
            szs 60
            jmp bsg
            lac i mx1
            dac t̄1
            mul t̄1
            scr 1s
            dac ācx
            cla
            scr 2s
            dio īox
            lac i my1
            dac t̄1
            mul t̄1
            scr 1s
            dac ācy
```

```
          cla
          scr 2s
          swap
          add i̅ox
          swap
          scl 2s
          add a̅cx
          add a̅cy
          sub str
          sma i sza-skp
          jmp pof
          add str
          varsft
          dac t̅1
          jda sqt
          mul t̅1
          undosft
          scr 9s
          scr 8s
          sza
          jmp bsg
          scr 1s
          dio t̅1
          integrate mx1, b̅x
          integrate my1, b̅y
bsg,      lac i mth
          jda cos
          dac c̅s
          sar 9s
          xct sac
          szf i 6
          cla
          add b̅y
          diff m̅dy, my1, (sar 3s
          lac s̅n
          sar 9s
          xct sac
          cma
          szf i 6
          cla
          add b̅x
          diff m̅dx, mx1, (sar 3s
          scale s̅n, 5s, s̅sn
          scale c̅s, 5s, s̅cn
          lac i mx1
          szs 20
          sub nx1
          sub s̅sn
          dac s̅x1
          sub s̅sn
          dac s̅tx
```

```
                lac i my1
                szs 20
                sub ny1
                add s̅cn
                dac s̅y1
                add s̅cn
                dac sty
                scale s̅n, 9s, ssn
                scale c̅s, 9s, scn
                dac s̅cm
                lac s̅sn
                dac s̅sm
                add s̅cn
                dac s̅sc
                dac s̅sd
                lac s̅sn
                sub s̅cn
                dac c̅sn
                cma
                dac c̅sm
                cla cli-opr
                szs 20
                jda kcb
                dpy-4000
mot,sp5,        jmp i .
sq6,            ioh
                lio s̅cw
                ril 2s
                spi i                   / not blasting
                jmp sq9                 / no tail
                ranct sar 9s, sar 4s, s̅rc
                scale s̅n, 8s, s̅sn
                scale c̅s, 8s, s̅cn
sq7,            count i mfu, st2
                dzm i mfu
                jmp sq9
st2,            yincr s̅x1, s̅y1, sub
                dispt i  s̅y1
                count s̅rc,sq7
sq9,            count i ma1, sr5        / check if torp tube reloaded
                dzm i ma1               / prevent count around
mco,            lac .                   / previous control word
                cma
                szs i 30
                clc
                and s̅cw   / present control word
                ral 3s                  / torpedo bit to bit 0
                sma
                jmp sr5                 / no launch
                count i m̅tr, st1       / check if torpedos exhausted
                dzm i m̅tr
                                                  / prevent count around
                jmp sr5
st1,            init sr1, mtb nob-1               /search for unused object
sr1,            lac .
                sza i                   / 0 if unused
                jmp sr2
                law i 1
                add sr1
                dap sr1
                sas (lac mtb-1
        jmp sr1
        hlt                    / no space for new objects
        jmp sr5


sr2,    lac (tcr               / set up torpedo calc
        dac i sr1
        law nob
        add sr1
        dap ss3
        lio s̅tx
ss3,    dio .
        add (nob
        dap ss4
        lio s̅ty
ss4,    dio .
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac s̅n
        xct tv1
        cma
        add i m̅dx
sr3,    dac .
        lac c̅s
        xct tv1
        add i m̅dy
sr4,    dac .
        xct rlt
        dac i ma               / permit torp tubes to cool
        xct tlf    / life of torpedo
sr6,    dac .
        lac (lac mtb nob-1
        sub sr1
        sal 3s
        add (30
sr7,    dap .                  / length of torp calc.
sr5,    lac s̅cw
        dac i mco
        count i mh3, mb1
        dzm i m̅h3
        lac i m̅h2
        sza i
        jmp mb1
        lac s̅cw
        and (600000
        xor (600000
        sza
        jmp mb1
        lac i ml1
        dac i m̅h1
        lac (hp1 400000
        dac i  ml1
        xct hd1
        dac i ma1
        law 2
        dac i mb1
```

```
/ here to handle spaceships dragged into star

/ spaceship in star

pof,        dzm i mdx
            dzm i mdy
            szs 50
            jmp po1
            lac (377777
            dac i mx1
            dac i my1
            lac i mb1
            dac ssn
            count ssn, .
            jmp mb1

po1,        lac (mex 400000      / now go bang
            dac i ml1
            law i 10
            dac i ma1
            jmp mb1

/ outlines of spaceships

ot1,        111131
            111111
            111111
            111163
            311111
            146111
            111114
            700000
. 5/

ot2,        013113
            113111
            116313
            131111
            161151
            111633
            365114
            700000
. 5/

            variables
            constants

.-64/
p,          . 100/               / space for patches
```

```
/display score routine

fss,        0           /set size of spaceship
            dap fs1
            lac fss
            dac s̄cm
            dac ss̄c
            dac s̄sd
            dac s̄cn
            dac cs̄m
            cma
            dac c̄sn
            dzm s̄sn
            dzm s̄sm
fs1,        jmp .

fi1,        law .       /set return of compiled outline
            sub c21
            dac t6
fi2,        law .
            sub c21
            dac t7
fis,        lac c23
            dac t4
            szf 3
            lio 2sc     /get score
            szf i 3
            lio 1sc
            scl 1s
            cla
            div c12
            hlt
            sza
            jmp fx1
fkr,        dio t3
            law 400
            jda fss
            law fys
            dap frt
flt,        idx t3
            cma
            dac t3
            law fus
            dap i t6
            dap i t7
fus,        lac c20
            szf 3
            cma
            dac sy1
            lac t4
            add c30
            dac t4
            dac sx1
```

```
fds,        szf 3       /display spaceship
            law not
            szf i 3
            law not 1
            dap fug
            idx t5
            ral 9s
            cli
            dpy-4000+700
            isp t3
fug,        jmp i .
frt,        jmp .

fys,        law 4000
            jda fss
            law fub
            dap i t6
            dap i t7
            lac c26
            dac sx1
            lac c20
            szf i 3
            cma
            add c30
            dac sy1
            law i 2
            dac t3
            jmp fds
fub,        szf 3
            jmp . 3
            stf 3
            jmp . 2
            clf 3
            iot 11
            dio t̄1
            iot 111
            dio t2
            law 1
            and t̄1
            and t̄2
            sza
            jmp fik
            law 2
            and t̄1
            and t̄2
            sza i
            jmp fis
            law a4+
            dap fiu
            jmp fwt
fik,        law 4
            dap fiu
fwt,        add .
            dac t̄1
            isp t̄1
            jmp .-1
fiu,        jmp .
```

```
fx1,        dio t̄1
            dac t3
            law fx2
            dap frt
            law 1100
            jda fss
            jmp flt
fx2,        lio t̄1
            jmp fkr

c12,        12
c20,        200000
c21,        21
c23,        -200000-30000
c26,        -260000
c30,        30000
t3,         0
t4,         0
t5,         0
t6,         0
t7,         0

mtb,                     / table of objects and their properties

start 4
```

```
spacewar 4.3  5/17/63  ddp  .  pt 1 - pass 1
spacewar 4.3  5/17/63   ddp  . pt 2 - pass 1
stars by prs  for s/w 2b - pass 1
f
nx1=mtb nob
f

nx1=mtb nob
ny1=nx1 nob
start
f - pass 1
spacewar 4.3  5/17/63  ddp  .  pt 1 - pass 2
spacewar 4.3  5/17/63   ddp  . pt 2 - pass 2
stars by prs  for s/w 2b - pass 2
spacewar 4.3 syms   5/23/63   jcm

Constants area, inclusive
from     to
2763     3111
```

1j	6077
1m	704
1q	6117
1sc	1323
2j	6121
2m	763
2q	6141
2sc	1324
3j	6143
3m	1042
3q	6403
4j	6405
4m	1121
4q	7747
8a	1520
8aa	1570
8ad	1543
8ao	1555
8aq	1562
8ax	1602
8ay	1533
8j1	1440
8j2	1444
a	1325
a1	1315
a2	1362
a3	1413
a4	1345
a40	1320
a5	1341
a6	1354
acx	2754
acy	2756
bc1	665
bc3	671
bcc	1200
bck	654
bcx	703
bcy	702
bds	542
bjm	541
bkc	1201
blp	466
blx	513
bpt	514
bpx	643
bsg	2336
bx	2731
by	2732
c12	3423
c21	3425
c23	3426
c26	3427
c20	3424

```
c30      3430
col      1603
cos      100
cox      1663
cs       2757
csm      2723
csn      2726
csx      146
cwg      2745
cwr      40
ddd      20
fds      3322
fi1      3255
fi2      3260
fid      25
fie      16
fik      3403
fin      7
fis      3263
fiu      3411
fkr      3277
flo      56
flp      46
flt      3304
foo      12
fou      15
fpo      55
fpr      1202
frr      14
frt      3335
fs       4
fs1      3254
fss      3240
fub      3355
fug      3334
fus      3312
fuu      35
fwt      3405
fx       36
fx1      3412
fx2      3421
fyn      20
fys      3336
gct      2746
grv      32
hd1      23
hd2      24
hd3      25
hp1      2015
hp3      2046
hp4      2107
hp6      2124
hp7      2122
hpt      2751
```

hr1	26
hr2	27
hur	30
idl	1456
ids	1470
iox	2755
kc1	2143
kcb	2132
ma1	1677
ma2	1700
maa	13
mb1	1503
mb2	1673
mco	2511
md1	1267
mdn	1273
mdx	2734
mdy	2735
me1	16
me2	17
mex	1701
mfu	2736
mg1	1435
mg2	1451
mg3	1450
mg4	1455
mh1	2740
mh2	2741
mh3	2742
mh4	2743
mhs	22
mi1	1736
ml1	1476
ml2	1625
ml0	1203
mom	2164
mot	2440
mq1	1506
mq2	1653
msh	1735
mst	1754
mt1	2747
mtb	3436
mtc	2733
mth	2200
mtr	2737
mx1	1630
mx2	1631
mxc	2750
my1	1640
my2	1641
mz1	1722
na1	3546
nb1	3576

nco	3720
ndx	3626
ndy	3656
nfu	3712
nh1	3722
nh2	3724
nh3	3726
nh4	3730
nnn	3732
nob	30
nom	3706
not	3716
ntd	2744
nth	3710
ntr	3714
nx1	3466
ny1	3516
oc	230
oc1	375
oc2	420
oc3	426
oc4	434
oc5	442
oc6	450
oc9	460
occ	2717
ocd	411
oce	402
ocg	252
och	253
oci	2720
ocj	250
ock	241
ocm	373
ocn	374
oco	264
ocp	266
ocq	265
ocr	267
ocs	222
ocx	372
ocz	227
ot1	2655
ot2	2672
p	3140
po1	2650
pof	2634
ran	31
rlt	10
sac	14
sbf	61
sc1	2152
scm	2721
scn	2710

```
scw       2752
sex       1667
sft       66
si1       112
si2       147
si3       117
sin       106
sn        2753
sp5       2440
sq1       220
sq2       221
sq3       171
sq6       2441
sq7       2466
sq9       2506
sqt       162
sqx       174
sr1       2527
sr2       2541
sr3       2570
sr4       2574
sr5       2606
sr6       2600
sr7       2605
src       2762
sr0       2152
ss1       2144
ss2       2147
ss3       2547
ss4       2553
ssa       2727
ssc       2725
ssd       2724
ssi       2730
ssm       2722
ssn       2707
st1       2525
st2       2472
str       15
stx       2760
sty       2761
sx1       2715
sy1       2716
t1        2712
t2        2713
t3        3431
t4        3432
t5        3433
t6        3434
t7        3435
tc1       1771
tcr       1756
the       21
tlf       11
```

tno	6
tvl	7
v2	3
xys	2711
xyt	2714

spacewar 4.2 5/11/63 ddp pt 1

```
3/          jmp sbf               / ignore seq. break
            jmp a40
            jmp a1      / use test word for control, not iot 11 co


/ interesting and often changed constants

/symb loc     usual value (all instructions are executed,
            / and may be replaced by jda or jsp)

tno,  6,    law i 41              / number of torps + 1
tvl,  7,    sar 4s      / torpedo velocity
rlt, 10,    law i 20    / torpedo reload time
tlf, 11,    law i 140             / torpedo life
foo, 12,    -20000      / fuel supply
maa, 13,    10          / spaceship angular acceleration
sac, 14,    sar 4s      / spaceship acceleration
str, 15,    100         / star capture radius
me1, 16,    6000        / collision "radius"
me2, 17,    3000        / above/2
ddd, 20,    -0          / 0 to save space for ddt
the, 21,    sar 9s      / amount of torpedo space warpage
mhs, 22,    law i 10    / number of hyperspace shots
hd1, 23,    law i 40    / time in hyperspace before breakout
hd2, 24,    law i 100             / time in hyperspace breakout
hd3, 25,    law i 200             / time to recharge hyperfield generators
hr1, 26,    scl 9s      / scale on hyperspatial displacement
hr2, 27,    scl 4s      / scale on hyperspatially induced velocity
hur, 30,    40000       / hyperspatial uncertancy
ran, 31,    0           / random number
grv, 32,    sar 6s      / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. Low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,        jmp mg1     / normally iot 11 control
. 20/       / space
```

```
/ routine to flush sequence breakes, if they occur.

sbf,      tyi
          lio 2
          lac 0
          lsm
          jmp i 1

          define
xincr X,Y,INS
          lac Y
          INS s̅sn
          dac Y
          lac X
          INS s̅cn
          dac X
          term

          define
yincr X,Y,INS
          lac Y
          INS s̅cn
          dac Y
          lac X
          -INS+add+sub s̅sn
          dac X
          terminate

          define
dispatch
          add (. 3
          dap . 1
          jmp .
          term

          define
dispt A,Y,B
          repeat 6  B=B+B
          lio Y
          dpy-A+B
          term

          define
scale A,B,C
          lac A
          sar B
          dac C
          term
          define
diff V,S,SF
          add i V
          dac i V
          xct SF
          add i S
          dac i S
          term


          define
random
          lac ran
          rar 1s
          xor (355670
          add (355670
          dac ran
          term

          define
ranct S,SS,C
          random
          S
          SS
          sma
          cma
          dac C
          terminate
```

```
define
          varsft
          dzm x̅ys
          dac t̅1
          idx x̅ys
v2,       idx x̅ys
          lac t̅1
          scr 2s
          dac t̅1
          sza
          jmp v2+R
          scr 2s
          swap
          terminate
define
          undosft
          dac t1
          dio t̅2
          lac x̅ys
          add sft
          dap .+1
          lac .
          dac .+6
          dac .+6
          xor (10000              / change scr to scl or scl to scr.
          dac x̅yt
          lac t̅1
          dio t̅2
          scr .
          scr .
          terminate
define
          integrate A,B
          cli
          lac i A
          scr 9s
          scr 1s
          div t̅1
          hlt
          cma+cli-opr
          xct x̅yt
          xct grv
          dac B
          terminate

sft,      lac .-1
          scr 7s
          scr 6s
          scr 5s
          scr 4s
          scr 3s
          scr 2s
          scr 1s
          scr
          scl 1s
```

```
/sine-cosine subroutine·Adams associates
/calling sequence= number in AC, jda sin or jdacos.
/argument is between +2 pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = 2.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,      0
          dap csx
          lac (62210
          add cos
          dac sin
          jmp .+4

sin,      0
          dap csx
          lac sin
          spa
si1,      add (311040
          sub (62210
          sma
          jmp si2
          add (62210

si3,      ral 2s
          mul (242763
          dac sin
          mul sin
          dac cos
          mul (756103
          add (121312
          mul cos
          add (532511
          mul cos
          add (144417
          mul sin
          scl 3s
          dac cos
          xor sin
          sma
          jmp csx-1
          lac (377777
          lio sin
          spi
          cma
          jmp csx

          lac cos
csx,      jmp .

si2,      cma
          add (62210
          sma
          jmp si3
          add (62210
          spa
          jmp .+3
          sub (62210
          jmp si3

          sub (62210
          jmp si1
```

```
/integer square root
/input in ac, binary point to right of bit 17, jda sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,      0
          dap sqx
          law i 23
          dac sq1
          dzm sq2
          lio sqt
          dzm sqt

sq3,      isp sq1
          jmp .+3
          lac sq2
sqx,      jmp .

          lac sq2
          sal 1s
          dac sq2
          lac sqt
          rcl 2s
          sza i
          jmp sq3
          dac sqt
          lac sq2
          sal 1s
          add (1
          sub sqt
          sma+sza-skp
          jmp sq3
          spa
          cma
          dac sqt
          idx sq2
          jmp sq3

sq1,      0
sq2,      0
```

```
/outline compiler
/ac=where to compile to, call    jda oc
                                /ot=address of outline table

define
         plinst A
         lac A
         dac i oc
         idx oc
         terminate

define
         comtab A, B
         plinst A
         jsp ocs
         lac B
         jmp oce
         terminate

ocs,     dap ocz                /puts in swap
         dio i oc
         idx oc
         dio i oc
         idx oc
ocz,     jmp .

oc,      0                      /outline compiler proper
         dap ocx
         lac i ocx
         dap ocg
         plinst (stf 5
         dap ocm
         idx ocx
ock,     plinst (lac s̄x1
         plinst (lio s̄y1
         clf 6
ocj,     setup ōcc,6
ocg,     lio .                  /outline table
och,     cla
         rcl 3̲s
         dio ōci
         lio (rcl 9s
         dispatch
         opr
         jmp oc1
oco,     jmp oc2
ocq,     jmp oc3
ocp,     jmp oc4
ocr,     jmp oc5
         jmp oc6
```

```
          plinst (szf 5       /7 code
          add (4
          dap ocn
          plinst ocn
          plinst (dac s̅x1
          plinst (dio s̅y1
          plinst (jmp sq6
          plinst (clf 5
          plinst (lac s̅cm
          plinst (cma
          plinst (dac s̅cm
          plinst (lac s̅sm
          plinst (cma
          plinst (dac s̅sm
          plinst (lac c̅sm
          plinst (lio s̅sd
          plinst (dac s̅sd
          plinst (dio c̅sm

          plinst (lac s̅sc
          plinst (lio c̅sn
          plinst (dac c̅sn
          plinst (dio s̅sc
          plinst ocm
ocx,      jmp .

ocm,      jmp .
ocn,      jmp .

oc1,      plinst (add s̅sn
          jsp ocs
          lac (sub s̅cn
oce,      dac i oc
          idx oc
          jsp ocs
          plinst (ioh
          lac (dpy-4000
ocd,      dac i oc
          idx oc
          lio o̅ci
          count o̅cc, och
          idx ocg
          jmp ocj

oc2,      comtab (add s̅cm, (add s̅sm
oc3,      comtab (add s̅sc, (sub c̅sm
oc4,      comtab (sub s̅cm, (sub s̅sm
oc5,      comtab (add c̅sn, (sub s̅sd
oc6,      szf 6
          jmp oc9
          stf 6
          plinst (dac s̅sa
          lac (dio s̅si
          jmp ocd
oc9,      clf 6
          plinst (lac s̅sa
          lac (lio s̅si
          jmp ocd
```

```
/display a star

define
          starp
          add b̄x
          swap
          add b̄y
          swap
          ioh
          dpy-4000
          terminate

blp,      dap blx             /star
          szs 60
          jmp blx
          random
          rar 9s
          and (400700
          spa
          xor (377777
          dac b̄x
          lac ran
          ral 4s
          and (400700
          spa
          xor (377777
          dac b̄y
          jsp bpt
          ioh
blx,      jmp .

bpt,      dap bpx
          random
          sar 9s
          sar 6s
          spa
          cma
          sal 3s
          add (bds
          dap bjm
          cla cli clf 6-opr-opr
          dpy-4000
bjm,      jmp .
bds,      repeat 10, starp
          szf 6
bpx,      jmp .
          stf 6
          cma
          swap
          cma
          swap
          jmp bjm
```

```
/background display · 3/13/62, prs.

          define
dislis J, Q
          dap fx+R
          clf 5
          lac flo+R
          dap fpo+R
fs,       dap fin+R
          dap fyn+R
          idx fyn+R

fin,      lac         /lac X
          sub fpr     /right margin
          sma
          sub (20000
          add (2000
frr,      spq
fou,      jmp fuu+R
fie,      sub (1000
          sal 8s
fyn,      lio         /lio Y
          dpy-i
          stf 5
fid,      idx fyn+R
          sad (lio Q+2
          jmp flp+R
          sad fpo+R
          jmp fx+R
          dap fin+R
          idx fyn+R
          jmp fin+R

fuu,      szf 5
fx,       jmp         /return
          idx flo+R
          idx flo+R
          sas (Q+2
          jmp fid+R
          law J
          dac flo+R
          jmp fid+R

flp,      lac (lio J
          sad fpo+R
          jmp fx+R
          dap fin+R
          law J+1
          dap fyn+R
          jmp fin+R

fpo,      lio
flo,      J
          terminate
          define
background
          jsp bck
          termin

bck,      dap bcx
          szs 40
          jmp bcx
          jsp 1m
          jsp 2m
          idx bcc
          and (1
          sza
          jsp 3m
bc1,      law 3
          and bcc
          sza i
          jsp 4m
bc3,      isp bkc
          jmp bcy
          law i 10
          dac bkc
          law i 1
          add fpr
          spa
          add (20000
          dac fpr
bcy,      jsp 1m
bcx,      jmp

1m,       dislis 1j, 1q
2m,       dislis 2j, 2q
3m,       dislis 3j, 3q
4m,       dislis 4j, 4q

bcc,      0
bkc,      0
fpr,      10000
```

```
mul=mus
div=dis


start
```

spacewar 4.2   5/16/63 ddp • pt 2

```
/main control routine for spaceships

nob=30                  /total number of colliding objects

ml0,    setup m̅tc, 5000                 /delay for loop
        init ml1, mtb   /loc of calc routines
        add (nob
        dap mx1         / x
nx1=mtb nob
        add (nob
        dap my1         / y
ny1=nx1 nob
        add (nob
        dap ma1         / count for length of explosion or torp
na1=ny1 nob
        add (nob
        dap mb1         / count of instructions taken by calc routine
nb1=na1 nob
        add (nob
        dac m̅dx         / dx
ndx=nb1 nob
        add (nob
        dac m̅dy         / dy
ndy=ndx nob
        add (nob
        dap mom         /angular velocity
nom=ndy nob
        add (2
        dap mth         / angle
nth=nom 2
        add (2
        dac m̅fu         /fuel
nfu=nth 2
        add (2
        dac m̅tr         / no torps remaining
ntr=nfu 2
        add (2
        dap mot         / outline of spaceship
not=ntr 2
        add (2
        dap mco         / old control word
nco=not 2
        add (2
        dac m̅h1
nh1=nco 2
        add (2
        dac m̅h2
nh2=nh1 2
        add (2
        dac m̅h3
nh3=nh2 2
        add (2
        dac m̅h4
nh4=nh3 2
nnn=nh4 2
```

```
        law ss1
        xor mtb
        sza
        jmp mdn
        law ss2
        xor mtb 1
        sza
        jmp mdn
        law 1       / test if both ships out of torps
        add ntr
        spa
        jmp md1
        law 1
        add ntr 1
        spa i
        jmp mdn
md1,    xct tlf     / restart delay is 2X torpedo life
        sal 1s
        dac n̄td
        jmp ml1

mdn,    count n̄td,ml1
        stf 1
        stf 2
        law ss1
        xor mtb
        sza
        clf 1
        sza i
        idx 1sc
        law ss2
        xor mtb 1
        sza
        clf 2
        sza i
        idx 2sc
        clf 2
        jmp a
```

```
a1,       law mg2          / test word control
          dac cwg
          jmp a

a40,      law cwr    / here from start at 4
          dac cwg
          jmp a6

1sc,      0          /scores
2sc,      0

a,        dzm 8j1
          dzm 8j2
          lac gct
          sma
          jmp a5
          count gct, a5
          lac 1sc
          sas 2sc
          jmp a4
          law i 1
          dac gct
a5,       lat
          and (40
          sza i
          jmp a2
a4,       jmp fi1
          lat
          and (40
          sza
          jmp a2
          dzm 1sc
          dzm 2sc
a6,       lat
          rar 6s
          and (37
          sza
          cma
          dac gct
a2,       clear mtb, nnn-1               / clear out all tables
          law ss1
          dac mtb
          law ss2
          dac mtb 1
          lac (200000
          dac nx1
          dac ny1
          cma
          dac nx1 1
          dac ny1 1
          lac (144420
          dac nth
```

```
        law nnn         / start of outline program
        dac not
        lio ddd
        spi i
        jmp a3
        jda oc          / compile outline
        ot1
a3,     dac not 1
        dap fi1
        jda oc
        ot2
        dap fi2
        xct tno
        dac ntr
        dac ntr 1
        lac foo
        dac nfu
        dac nfu+1
        law 2000
        dac nb1
        dac nb1 1
        xct mhs
        dac nh2
        dac nh2 1
        jmp m10
```

```
/ control word get routines

mg1,    dap mg3
        iot 11
        jsp 8a
8j1,    0
        dac t̅1
        iot 111
        jsp 8a
8j2,    0
        lio t̅1
        ril 4s
        rcr 4s
mg3,    jmp .

mg2,    dap mg4
        lat
        swap
mg4,    jmp .

idl,    idx mth
        idx m̅fu
        idx m̅tr
        idx mco
        idx mot
        idx mom
        idx m̅h1
        idx m̅h2
        idx m̅h3
        idx m̅h4
ids,    idx mx1
        idx my1
        idx ma1
        idx mb1
        idx m̅dy
        idx m̅dx
ml1,    lac .              / 1st control word
        sza i              / zero if not active
        jmp mq1            / not active
        dap . 1
        jmp .
mb1,    lac .              / alter count of number of instructions
        add m̅tc
        dac m̅tc
mq1,    idx ml1
        sad (lac mtb 1
        jmp idl
        sas (lac mtb nob
        jmp ids
        background
        jsp blp            / display massive star
        count m̅tc, .       / use up rest of time of main loop
        jmp ml0            / repeat whole works
```

```
8a,       dap 8ay
          dap 8ax
          idx 8ax
          clf 7
          spi
          stf 5
          szf i 5
          stf 6
          ril 1
          spi
          jmp 8ao

8ay,      lac
          rir 8s
          spi
          cla
          rir 1s
          spi
          law 2
          dac i 8ay

8ad,      rir 8s
          spi
          jmp 8aq
          rir 5s
          spi
          ior (14
          rir 1s
          spi
          ior (1
          jmp 8aa

8ao,      cla
          rir 9s
          spi
          law 2
          jmp 8ad

8aq,      rir 5s
          spi
          ior (1
          rir 1s
          spi
          ior (14
8ar,      rir 1s
          spi 5
          ior (4
          spi 6
          ior (10
          rir 1s
          spi 5
          ior (10
          spi 6
          ior (4
8ax,      jmp
```

```
col,    dap cox
        law 1
        add ml1
        sad (lac mtb nob
        jmp cox-1
        dap ml2
        law 1
        add mx1
        dap mx2
        law 1
        add my1
        dap my2
        law 1
        add ma1
        dap ma2
        law 1
        add mb1
        dap mb2
ml2,    lac .               / 2nd control word
        spq            / can it collide?
        jmp mq2             / no
mx1,    lac .               / calc if collision
mx2,    sub .               / delta x
        spa                 / take abs val
        cma
        dac mt1
        sub me1             / < EPSILON ?
        sma
        jmp mq2             / no
my1,    lac .
my2,    sub .
        spa
        cma
        sub me1             / < epsilon ?
        sma
        jmp mq2             / no
        add mt1
        sub me2
        spa
        jmp cox
mq2,    idx mx2             / end of comparison loop
        idx my2
        idx ma2
        idx mb2
        index ml2, (lac mtb nob, ml2
        idx cox
cox,    jmp .
```

```
/routine to set explosion

        law 20
        dac i mb1
        dac i mb2
sex,    lac (mex 400000                  /EXPLODE
        dac i ml1       / replace calc routine with explosion
        dac i ml2
        lac i mb1       / duration of explosion
mb2,    add .
        cma
        sar 8s
        add (1
ma1,    dac .
ma2,    dac .

/ misc calculation routines

        / explosion

mex,    lac i mdx
        sar 3s
        add i mx1
        dac i mx1
        lac i mdy
        sar 3s
        add i my1
        dac i my1
        law mst
        dap msh
        lac i mb1       / time involved
        cma cli-opr
        sar 3s
        dac mxc
        sub (140
        sma
        idx msh
mz1,    lac ran
        and (777
        ior (scl
        dac mi1
        random
        scr 9s
        sir 9s
msh,    xct .
mi1,    hlt
        add i my1
        swap
        add i mx1
        dpy-i 300
        count mxc, mz1
        count i ma1, mb1
        dzm i ml1
        jmp mb1

mst,    scr 1s
        scr 3s
```

```
/ torpedo calc routine

tcr,    jsp col
        jmp sex-3
        count i ma1, tc1
        lac (mex 400000
        dac i ml1
        law i 2
        dac i ma1
        law 20
        dac i mb1
        jmp mb1

tc1,    lac i mx1
        sar 9s
        xct the
        add i m̅dy
        dac i m̅dy
        sar 3s
        add i my1
        dac i my1
        sar 9s
        xct the
        add i m̅dx
        dac i m̅dx
        sar 3s
        add i mx1
        dac i mx1
        dispt i, i my1, 1
        jmp mb1

/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,    count i ma1, mb1
        law hp3         / next step
        dac i ml1
        law 7
        dac i mb1
        random
        scr 9s
        sir 9s
        xct hr1
        add i mx1
        dac i mx1
        swap
        add i my1
        dac i my1
        dzm i mdx
        dzm i mdy
        xct hd2
        dac i ma1
        jmp mb1
```

```
/ this routine handles a ship breaking out of
/ hyperspace.

hp3,    jsp col
        jmp sex
        count i ma1,hp6
        law 2000
        dac i mb1
        lac i m̅h4
        add hur
        dac i m̅h4
        random
        ior (400000
        add i m̅h4
        sma
        jmp po1
        lac i m̅h1
        dac i ml1
        lac ran
        scr 9s
        sir 9s
        xct hr2
        dac i mdy
        dio i mdx
        setup h̅pt,3
        lac ran
        dac i mth
hp4,    lac i mth
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        count h̅pt,hp4
        count i m̅h2,hp7
        dzm i m̅h2
hp7,    xct hd3
        dac i m̅h3
hp6,    lac i mx1
        dispt i, i my1, 2
        jmp mb1
```

```
/ spaceship calc
ss1,     jsp i cwg
         dio scw
         jmp sr0

ss2,     jsp i cwg
         rir 4s
         dio scw

sr0,
sc1,     clf 6
         jsp col
         jmp sex
         lio scw
         clf 6 cla-opr  /update angle
         spi
         add maa
         ril 1s
         spi
         sub maa
mom,     add .
         dac i mom
         szs 10
         jmp . 3
         dzm i mom
         ral 7s
         ril 1s
         spi
         stf 6
         lio i mfu
         spi i
         clf 6

mth,     add .
         sma
         sub (311040
         spa
         add (311040
         dac i mth
         jda sin
         dac sn
         dzm bx
         dzm by
         szs 60
         jmp bsg
         lac i mx1
         dac t1
         mul t1
         scr 1s
         dac acx
         cla
         scr 2s
         dio iox
         lac i my1
         dac t1
         mul t1
         scr 1s
         dac acy
```

```
          cla
          scr 2s
          swap
          add iox
          swap
          scl 2s
          add acx
          add acy
          sub str
          sma i sza-skp
          jmp pof
          add str
          varsft
          dac t1
          jda sqt
          mul t1
          undosft
          scr 9s
          scr 6s
          szs i 20          / switch 2 for light star
          scr 2s
          sza
          jmp bsg
          scr 1s
          dio t1
          integrate mx1, bx
          integrate my1, by
bsg,      lac i mth
          jda cos
          dac cs
          sar 9s
          xct sac
          szf i 6
          cla
          add by
          diff mdy, my1, (sar 3s
          lac sn
          sar 9s
          xct sac
          cma
          szf i 6
          cla
          add bx
          diff mdx, mx1, (sar 3s
          scale sn, 5s, ssn
          scale cs, 5s, scn
          lac i mx1
          sub ssn
          dac sx1
          sub ssn
          dac stx
```

```
        lac i my1
        add scn
        dac sy1
        add scn
        dac sty
        scale sn, 9s, ssn
        scale cs, 9s, scn
        dac scm
        lac ssn
        dac ssm
        add scn
        dac ssc
        dac ssd
        lac ssn
        sub scn
        dac csn
        cma
        dac csm
        cla cli-opr
        dpy-4000
mot,sp5,          jmp i .
sq6,    ioh
        lio scw
        ril 2s
        spi i           / not blasting
        jmp sq9         / no tail
        ranct sar 9s, sar 4s, src
        scale sn, 8s, ssn
        scale cs, 8s, scn
sq7,    count i mfu, st2
        dzm i mfu
        jmp sq9
st2,    yincr sx1, sy1, sub
        dispt i, sy1
        count src,sq7
sq9,    count i ma1, sr5            / check if torp tube reloaded
        dzm i ma1       / prevent count around
mco,    lac .           / previous control word
        cma
        szs i 30
        clc
        and scw    / present control word
        ral 3s          / torpedo bit to bit 0
        sma
        jmp sr5         / no launch
        count i mtr, st1            / check if torpedos exhausted
        dzm i mtr                   / prevent count around
        jmp sr5
st1,    init sr1, mtb nob-1         /search for unused object
sr1,    lac .
        sza i           / 0 if unused
        jmp sr2
        law i 1
        add sr1
        dap sr1
        sas (lac mtb-1
        jmp sr1
        hlt             / no space for new objects
        jmp sr5
```

```
sr2,    lac (tcr        / set up torpedo calc
        dac i sr1
        law nob
        add sr1
        dap ss3
        lio stx
ss3,    dio .
        add (nob
        dap ss4
        lio sty
ss4,    dio .
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac sn
        xct tvl
        cma
        add i mdx
sr3,    dac .
        lac cs
        xct tvl
        add i mdy
sr4,    dac .
        xct rlt
        dac i ma1       / permit torp tubes to cool
        xct tlf    / life of torpedo
sr6,    dac .
        lac (lac mtb nob-1
        sub sr1
        sal 3s
        add (30
sr7,    dap .           / length of torp calc.
sr5,    lac scw
        dac i mco
        count i mh3, mb1
        dzm i mh3
        lac i mh2
        sza i
        jmp mb1
        lac scw
        and (600000
        xor (600000
        sza
        jmp mb1
        lac i ml1
        dac i mh1
        lac (hp1 400000
        dac i  ml1
        xct hd1
        dac i ma1
        law 2
        dac i mb1
        jmp mb1
```

```
/ here to handle spaceships dragged into star

/ spaceship in star

pof,    dzm i m̅dx
        dzm i m̅dy
        szs 50
        jmp po1
        lac (377777
        dac i mx1
        dac i my1
        lac i mb1
        dac s̅sn
        count s̅sn, .
        jmp mb1

po1,    lac (mex 400000                 / now go bang
        dac i ml1
        law i 10
        dac i ma1
        jmp mb1

/ outlines of spaceships

ot1,    111131
        111111
        111111
        111163
        311111
        146111
        111114
        700000
. 5/

ot2,    013113
        113111
        116313
        131111
        161151
        111633
        365114
        700000
. 5/


        variables
        constants


.-64/
p,      . 100/          / space for patches
```

```
/display score routine

fss,    0               /set size of spaceship
        dap fs1
        lac fss
        dac s̅cm
        dac ss̅c
        dac s̅sd
        dac s̅cn
        dac cs̅m
        cma
        dac c̅sn
        dzm s̅sn
        dzm s̅sm
fs1,    jmp .

fi1,    law .           /set return of compiled outline
        sub c21
        dac t6
fi2,    law .
        sub c21
        dac t7
fis,    lac c23
        dac t4
        szf 3
        lio 2sc         /get score
        szf i 3
        lio 1sc
        scl 1s
        cla
        div c12
        hlt
        sza
        jmp fx1
fkr,    dio t3
        law 400
        jda fss
        law fys
        dap frt
flt     idx t3
        cma
        dac t3
        law fus
        dap i t6
        dap i t7
fus,    lac c20
        szf 3
        cma
        dac sy1
        lac t4
        add c30
        dac t4
        dac sx1
```

```
fds,    szf 3      /display spaceship
        law not
        szf i 3
        law not 1
        dap fug
        idx t5
        ral 9s
        cli
        dpy-4000+700
        isp t3
fug,    jmp i .
frt,    jmp .

fys,    law 4000
        jda fss
        law fub
        dap i t6
        dap i t7
        lac c26
        dac sx1
        lac c20
        szf i 3
        cma
        add c30
        dac sy1
        law i 2
        dac t3
        jmp fds
fub,    szf 3
        jmp . 3
        stf 3
        jmp . 2
        clf 3
        iot 11
        dio t̄1
        iot 111
        dio t2
        law 1
        and t̄1
        and t̄2
        sza
        jmp fik
        law 2
        and t̄1
        and t̄2
        sza i
        jmp fis
        law a4+1
        dap fiu
        jmp fwt
fik,    law 4
        dap fiu
fwt,    add .
        dac t̄1
        isp t̄1
        jmp .-1
fiu,    jmp .
```

```
fx1,    dio t̄1
        dac t3
        law fx2
        dap frt
        law 1100
        jda fss
        jmp flt
fx2,    lio t̄1
        jmp fkr

c12,    12
c20,    200000
c21,    21
c23,    -200000-30000
c26,    -260000
c30,    30000
t3,     0
t4,     0
t5,     0
t6,     0
t7,     0

mtb,                / table of objects and their properties

start 4
```

```
spacewar 4.2  5/11/63  ddp :  pt 1 - pass 1
spacewar 4.2   5/16/63  ddp  : pt 2 - pass 1
stars by prs  for s/w 2b - pass 1
spacewar 4.2  5/11/63  ddp :  pt 1 - pass 2
spacewar 4.2   5/16/63  ddp  : pt 2 - pass 2
stars by prs  for s/w 2b - pass 2
spacewar 4.2 syms   5/2363  jcm

Constants area, inclusive
from     to
2714     3042
```

j	6077
1m	676
1q	6117
1sc	1305
2j	6121
2m	753
2q	6141
2sc	1306
3j	6143
3m	1030
3q	6403
4j	6405
4m	1105
4q	7747
8a	1502
8aa	1552
8ad	1525
8ao	1537
8aq	1544
8ax	1564
8ay	1515
8j1	1422
8j2	1426
a	1307
a1	1277
a2	1344
a3	1375
a4	1327
a40	1302
a5	1323
a6	1336
acx	2705
acy	2707
bc1	657
bc3	663
bcc	1162
bck	646
bcx	675
bcy	674
bds	534
bjm	533
bkc	1163
blp	466
blx	513
bpt	514
bpx	635
bsg	2277
bx	2662
by	2663
c12	3354
c21	3356
c23	3357
c26	3360
c20	3355

```
c30        3361
col        1565
cos        100
cox        1645
cs         2710
csm        2654
csn        2657
csx        146
cwg        2676
cwr        40
ddd        20
fds        3253
fi1        3206
fi2        3211
fid        23
fie        16
fik        3334
fin        7
fis        3214
fiu        3342
fkr        3230
flo        54
flp        44
flt        3235
foo        12
fou        15
fpo        53
fpr        1164
frr        14
frt        3266
fs         4
fs1        3205
fss        3171
fub        3306
fug        3265
fus        3243
fuu        33
fwt        3336
fx         34
fx1        3343
fx2        3352
fyn        20
fys        3267
gct        2677
grv        32
hd1        23
hd2        24
hd3        25
hp1        1773
hp3        2024
hp4        2062
hp6        2077
hp7        2075
hpt        2702
```

hr1	26
hr2	27
hur	30
idl	1440
ids	1452
iox	2706
ma1	1661
ma2	1662
maa	13
mb1	1465
mb2	1655
mco	2442
md1	1251
mdn	1255
mdx	2665
mdy	2666
me1	16
me2	17
mex	1663
mfu	2667
mg1	1417
mg2	1433
mg3	1432
mg4	1437
mh1	2671
mh2	2672
mh3	2673
mh4	2674
mhs	22
mi1	1720
ml1	1460
ml2	1607
ml0	1165
mom	2123
mot	2373
mq1	1470
mq2	1635
msh	1717
mst	1734
mt1	2700
mtb	3367
mtc	2664
mth	2137
mtr	2670
mx1	1612
mx2	1613
mxc	2701
my1	1622
my2	1623
mz1	1704
na1	3477
nb1	3527
nco	3651
ndx	3557

ndy	3607
nfu	3643
nh1	3653
nh2	3655
nh3	3657
nh4	3661
nnn	3663
nob	30
nom	3637
not	3647
ntd	2675
nth	3641
ntr	3645
nx1	3417
ny1	3447
oc	230
oc1	375
oc2	420
oc3	426
oc4	434
oc5	442
oc6	450
oc9	460
occ	2650
ocd	411
oce	402
ocg	252
och	253
oci	2651
ocj	250
ock	241
ocm	373
ocn	374
oco	264
ocp	266
ocq	265
ocr	267
ocs	222
ocx	372
ocz	227
ot1	2606
ot2	2623
p	3071
po1	2601
pof	2565
ran	31
rlt	10
sac	14
sbf	61
sc1	2111
scm	2652
scn	2641
scw	2703
sex	1651

```
sft        66
si1        112
si2        147
si3        117
sin        106
sn         2704
sp5        2373
sq1        220
sq2        221
sq3        171
sq6        2374
sq7        2421
sq9        2437
sqt        162
sqx        174
sr1        2460
sr2        2472
sr3        2521
sr4        2525
sr5        2537
sr6        2531
sr7        2536
src        2713
sr0        2111
ss1        2103
ss2        2106
ss3        2500
ss4        2504
ssa        2660
ssc        2656
ssd        2655
ssi        2661
ssm        2653
ssn        2640
st1        2456
st2        2425
str        15
stx        2711
sty        2712
sx1        2646
sy1        2647
t1         2643
t2         2644
t3         3362
t4         3363
t5         3364
t6         3365
t7         3366
tc1        1751
tcr        1736
the        21
tlf        11
tno        6
tvl        7
```

```
v2          3
xys         2642
xyt         2645
```

```
spacewar 4.0  2/2/63 ddp : pt. 1

3/      jmp sbf                     / ignore seq. break
        jmp a40
        jmp a1                / use test word for control, not iot 11 co


/ interesting and often changed constants

/symb loc   usual value (all instructions are executed,
        / and may be replaced by jda or jsp)

tno,  6,     law i 41         / number of torps + 1
tvl,  7,     sar 4s           / torpedo velocity
rlt, 10,     law i 20         / torpedo reload time
tlf, 11,     law i 140        / torpedo life
foo, 12,     -20000           / fuel supply
maa, 13,     10               / spaceship angular acceleration
sac, 14,     sar 4s           / spaceship acceleration
str, 15,     100              / star capture radius
me1, 16,     6000             / collision "radius"
me2, 17,     3000             / above/2
ddd, 20,     -0               / 0 to save space for ddt
the, 21,     sar 9s           / amount of torpedo space warpage
mhs, 22,     law i 10         / number of hyperspace shots
hd1, 23,     law i 40         / time in hyperspace before breakout
hd2, 24,     law i 100        / time in hyperspace breakout
hd3, 25,     law i 200        / time to recharge hyperfield generators
hr1, 26,     scl 9s           / scale on hyperspatial displacement
hr2, 27,     scl 4s           / scale on hyperspatially induced velocity
hur, 30,     40000            / hyperspatial uncertancy
ran, 31,     0                / random number
grv, 32,     sar 6s           / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. Low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,    jmp mg1               / normally iot 11 control
. 20/   / space
```

```
/ routine to flush sequence breakes, if they occur.

sbf,    tyi
        lio 2
        lac 0
        lsm
        jmp i 1

        define
xincr X,Y,INS
        lac Y̲
        INS s̄sn
        dac Y
        lac X̲
        INS s̄cn
        dac X
        term

        define
yincr X,Y,INS
        lac Y̲
        INS s̄cn
        dac Y
        lac X
        -INS+add+sub s̄sn
        dac X
        terminate

        define
dispatch
        add (. 3
        dap . 1
        jmp .
        term

        define
dispt A,Y,B
        repeat 6     B=B+B
        lio Y
        dpy-A+B
        term

        define
scale A,B,C
        lac A
        sar B
        dac C
        term
        define
diff V,S,SF
        add i V
        dac i V
        xct SF
        add i S
        dac i S
        term


        define
random
        lac ran
        rar 1s
        xor (355670
        add (355670
        dac ran
        term

        define
ranct S,SS,C
        random
        S
        SS
        sma
        cma
        dac C
        terminate
```

```
define
        varsft
        dzm x̅ys
        dac t̅1
        idx x̅ys
v2,     idx x̅ys
        lac t̅1
        scr 2s
        dac t̅1
        sza
        jmp v2+R
        scr 2s
        swap
        terminate
define
        undosft
        dac t1
        dio t̅2
        lac x̅ys
        add sft
        dap .+1
        lac .
        dac .+6
        dac .+6
        xor (10000    / change scr to scl or scl to scr.
        dac x̅yt
        lac t̅1
        dio t̅2
        scr .
        scr .
        terminate
define
        integrate A,B
        cli
        lac i A
        scr 9s
        scr 1s
        div t̅1
        hlt
        cma+cli-opr
        xct x̅yt
        xct grv
        dac B
        terminate

sft,    lac .-1
        scr 7s
        scr 6s
        scr 5s
        scr 4s
        scr 3s
        scr 2s
        scr 1s
        scr
        scl 1s
```

```
/sine-cosine subroutine·Adams associates
/calling sequence= number in AC, jda sin or jdacos.
/argument is between +2 pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = 2.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,    0
        dap csx
        lac (62210
        add cos
        dac sin
        jmp .+4

sin,    0
        dap csx
        lac sin
        spa
si1,    add (311040
        sub (62210
        sma
        jmp si2
        add (62210

si3,    ral 2s
        mul (242763
        dac sin
        mul sin
        dac cos
        mul (756103
        add (121312
        mul cos
        add (532511
        mul cos
        add (144417
        mul sin
        scl 3s
        dac cos
        xor sin
        sma
        jmp csx-1
        lac (377777
        lio sin
        spi
        cma
        jmp csx

        lac cos
csx,    jmp .

si2,    cma
        add (62210
        sma
        jmp si3
        add (62210
        spa
        jmp .+3
        sub (62210
        jmp si3

        sub (62210
        jmp si1
```

```
/integer square root
/input in ac, binary point to right of bit 17, jda sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,    0
        dap sqx
        law i 23
        dac sq1
        dzm sq2
        lio sqt
        dzm sqt

sq3,    isp sq1
        jmp .+3
        lac sq2
sqx,    jmp .

        lac sq2
        sal 1s
        dac sq2
        lac sqt
        rcl 2s
        sza i
        jmp sq3
        dac sqt
        lac sq2
        sal 1s
        add (1
        sub sqt
        sma+sza-skp
        jmp sq3
        spa
        cma
        dac sqt
        idx sq2
        jmp sq3

sq1,    0
sq2,    0
```

```
/outline compiler
/ac=where to compile to, call   jda oc
                                /ot=addres of outline table

define
        plinst A
        lac A
        dac i oc
        idx oc
        terminate

define
        comtab A, B
        plinst A
        jsp ocs
        lac B
        jmp oce
        terminate

ocs,    dap ocz                 /puts in swap
        dio i oc
        idx oc
        dio i oc
        idx oc
ocz,    jmp .

oc,     0                       /outline compiler proper
        dap ocx
        lac i ocx
        dap ocg
        plinst (stf 5
        dap ocm
        idx ocx
ock,    plinst (lac s̅x1
        plinst (lio s̅y1
        clf 6
ocj,    setup o̅cc,6
ocg,    lio .                   /outline table
och,    cla
        rcl 3s
        dio o̅ci
        lio (rcl 9s
        dispatch
        opr
        jmp oc1
oco,    jmp oc2
ocq,    jmp oc3
ocp,    jmp oc4
ocr,    jmp oc5
        jmp oc6
        plinst (szf 5       /7 code
        add (4
        dap ocn
        plinst ocn
        plinst (dac s̄x1
        plinst (dio s̄y1
        plinst (jmp sq6
        plinst (clf 5
        plinst (lac s̄cm
        plinst (cma
        plinst (dac s̄cm
        plinst (lac s̄sm
        plinst (cma
        plinst (dac s̄sm
        plinst (lac c̄sm
        plinst (lio s̄sd
        plinst (dac s̄sd
        plinst (dio c̄sm

        plinst (lac s̄sc
        plinst (lio c̄sn
        plinst (dac c̄sn
        plinst (dio s̄sc
        plinst ocm
ocx,    jmp .

ocm,    jmp .
ocn,    jmp .

oc1,    plinst (add s̄sn
        jsp ocs
        lac (sub s̄cn
oce,    dac i oc
        idx oc
        jsp ocs
        plinst (ioh
        lac (dpy-4000
ocd,    dac i oc
        idx oc
        lio ōci
        count ōcc, och
        idx ocg
        mp ocj

oc2,    comtab (add s̄cm, (add s̄sm
oc3,    comtab (add s̄sc, (sub c̄sm
oc4,    comtab (sub s̄cm, (sub s̄sm
oc5,    comtab (add c̄sn, (sub s̄sd
oc6,    szf 6
        jmp oc9
        stf 6
        plinst (dac s̄sa
        lac (dio s̄si
        jmp ocd
oc9,    clf 6
        plinst (lac s̄sa
        lac (lio s̄si
        jmp ocd
```

```
/display a star

define
        starp
        add b̄x
        swap
        add b̄y
        swap
        ioh
        dpy-4000
        terminate

blp,    dap blx                 /star
        szs 60
        jmp blx
        random
        rar 9s
        and (add 340
        spa
        xor (377777
        dac b̄x
        lac ran
        ral 4s
        and (add 340
        spa
        xor (377777
        dac b̄y
        jsp bpt
        ioh
blx,    jmp .

bpt,    dap bpx
        random
        sar 9s
        sar 5s
        spa
        cma
        sal 3s
        add (bds
        dap bjm
        cla cli clf 6-opr-opr
        dpy-4000
bjm,    jmp .
bds,    repeat 20, starp
        szf 6
bpx,    jmp .
        stf 6
        cma
        swap
        cma
        swap
        jmp bjm
```

```
/background display • 3/13/62, prs.

        define
dislis J, Q, B
        repeat 6, B=B+B
        clf 5
        lac flo+R
        dap fpo+R
fs,     dap fin+R
        dap fyn+R
        idx fyn+R

fin,    lac             /lac X
        sub fpr         /right margin
        sma
        jmp fgr+R
        add (2000
frr,    spq
fou,    jmp fuu+R
fie,    sub (1000
        sal 8s
fyn,    lio             /lio Y
        dpy-i+B
        stf 5
fid,    idx fyn+R
        sad (lio Q+2
        jmp flp+R
        sad fpo+R
        jmp fx+R
        dap fin+R
        idx fyn+R
        jmp fin+R

fgr,    add (-20000+2000
        jmp frr+R

fuu,    szf 5
fx,     jmp flo+R+1     /return
        idx flo+R
        idx flo+R
        sas (Q+2
        jmp fid+R
        law J
        dac flo+R
        jmp fid+R

flp,    lac (lio J
        sad fpo+R
        jmp fx+R
        dap fin+R
        law J+1
        dap fyn+R
        jmp fin+R

fpo,    lio
flo,    J
        terminate
        define
background
        jsp bck
        termin

bck,    dap bcx
        szs 40
        jmp bcx
        isp bcc
bcx,    jmp .
        law i 2
        dac bcc
        dislis 1j,1q,3
        dislis 2j,2q,2
        dislis 3j,3q,1
        dislis 4j,4q,0
        isp bkc
        jmp bcx
        law i 20
        dac bkc
        law i 1
        add fpr
        spa
        add (20000
        dac fpr
        jmp bcx

bcc,    0
bkc,    0
fpr,    10000
```

```
mul=mus
div=dis


start
```

```
spacewar 4.0   ddp   2/2/63   pt.2

/main control routine for spaceships

nob=30                             /total number of colliding objects

ml0,      load mtc, -4000          /delay for loop
          init ml1, mtb            /loc of calc routines
          add (nob
          dap mx1                  / x
nx1=mtb   nob
          add (nob
          dap my1                  / y
ny1=nx1   nob
          add (nob
          dap ma1                  / count for length of explosion or torp
na1=ny1   nob
          add (nob
          dap mb1                  / count of instructions taken by calc routine
nb1=na1   nob
          add (nob
          dac mdx                  / dx
ndx=nb1   nob
          add (nob
          dac mdy                  / dy
ndy=ndx   nob
          add (nob
          dap mom                  /angular velocity
nom=ndy   nob
          add (2
          dap mth                  / angle
nth=nom   2
          add (2
          dac mfu                  /fuel
nfu=nth   2
          add (2
          dac mtr                  / no torps remaining
ntr=nfu   2
          add (2
          dap mot                  / outline of spaceship
not=ntr   2
          add (2
          dap mco                  / old control word
nco=not   2
          add (2
          dac mh1
nh1=nco   2
          add (2
          dac mh2
nh2=nh1   2
          add (2
          dac mh3
nh3=nh2   2
          add (2
          dac mh4
nh4=nh3   2
nnn=nh4   2
```

```
        law ss1
        xor mtb
        sza
        jmp mdn
        law ss2
        xor mtb 1
        sza
        jmp mdn
        law 1           / test if both ships out of torps
        add ntr
        spa
        jmp md1
        law 1
        add ntr 1
        spa i
        jmp mdn
md1,    xct tlf         / restart delay is 2X torpedo life
        sal 1s
        dac n̅td
        jmp ml1

mdn,    count n̅td,ml1
        stf 1
        stf 2
        law ss1
        xor mtb
        sza
        clf 1
        sza i
        idx 1̅sc
        law ss2
        xor mtb 1
        sza
        clf 2
        sza i
        idx 2̅sc
        clf 2
        jmp a
```

```
a1,        law mg2              / test word control
           dac c̅wg
           jmp a

a40,       law cwr        / here from start at 4
           dac c̅wg
           jmp a6

a,         lac g̅ct
           sma
           jmp a5
           count g̅ct, a5
           lac 1̅sc
           sas 2̅sc
           jmp a4
           law i 1
           dac g̅ct
a5,        lat
           and (40
           sza i
           jmp a2
a4,        lac 1̅sc
           lio 2̅sc
           hlt
           lat
           and (40
           sza
           jmp a2
           dzm 1̅sc
           dzm 2̅sc
a6,        lat
           rar 6s
           and (37
           sza
           cma
           dac g̅ct
a2,        clear mtb, nnn-1     / clear out all tables
           law ss1
           dac mtb
           law ss2
           dac mtb 1
           lac (200000
           dac nx1
           dac ny1
           cma
           dac nx1 1
           dac ny1 1
           lac (144420
           dac nth
```

```
          law nnn            / start of outline program
          dac not
          lio ddd
          spi i
          jmp a3
          jda oc             / compile outline
          ot1
a3,       dac not 1
          jda oc
          ot2
          xct tno
          dac ntr
          dac ntr 1
          lac foo
          dac nfu
          dac nfu+1
          law 2000
          dac nb1
          dac nb1 1
          xct mhs
          dac nh2
          dac nh2 1
          jmp m10
```

```
/ control word get routines

mg1,    dap mg3
        cli
        iot 11
mg3,    jmp .

mg2,    dap mg4
        lat
        swap
mg4,    jmp .

ml1,    lac .                  / 1st control word
        sza i                  / zero if not active
        jmp mq1                / not active
        swap
        idx m̄oc
        spi
        jmp mq4
        law 1
        add ml1
        dap ml2
        law 1
        add mx1
        dap mx2
        law 1
        add my1
        dap my2
        law 1
        add ma1
        dap ma2
        law 1
        add mb1
        dap mb2
mot,    lac .
        dap sp5
ml2,    lac .                  / 2nd control word
        spq              / can it collide?
        jmp mq2                / no
mx1,    lac .                  / calc if collision
mx2,    sub .                  / delta x
        spa                    / take abs val
        cma
        dac m̄t1
        sub me1                / < EPSILON ?
        sma
        jmp mq2                / no
my1,    lac .
my2,    sub .
        spa
        cma
        sub me1                / < epsilon ?
        sma
        jmp mq2                / no
        add m̄t1
        sub me2
        sma
        jmp mq2
        lac (mex 400000    / yes, EXPLODE
        dac i ml1    / replace calc routine with explosion
        dac i ml2
        lac i mb1    / duration of explosion
mb2,    add .
        cma
        sar 8s
        add (1
ma1,    dac .
ma2,    dac .
mq2,    idx mx2            / end of comparison loop
        idx my2
        idx ma2
        idx mb2
        index ml2, (lac mtb nob, ml2
mq4,    lac i ml1    / routine for calculating spaceship
        dap . 1            / or other object and displaying it
        jsp .
mb1,    lac .              / alter count of number of instructions
        add m̄tc
        dac m̄tc
mq1,    idx mx1            / end of comparison and display loop
        idx my1
        idx ma1
        idx mb1
        idx m̄dx
        idx m̄dy
        idx mom
        idx mth
        idx m̄as
        idx m̄fu
        idx m̄tr
        idx mot
        idx mco
        idx m̄h1
        idx m̄h2
        idx m̄h3
        idx m̄h4
        index ml1, (lac mtb nob-1, ml1
        lac i ml1    / display and compute last point
        sza i              / if active
        jmp mq3
        dap . 1
        jsp .
        lac i mb1
        add m̄tc
        dac m̄tc
mq3,    background   / display stars of the heavens
        jsp blp            / display massive star
        count m̄tc, .       / use up rest of time of main loop
        jmp m10            / repeat whole works
```

```
/ misc calculation routines

        / explosion

mex,    dap mxr
        lac i m̄dx
        sar 3s
        add i mx1
        dac i mx1
        lac i m̄dy
        sar 3s
        add i my1
        dac i my1
        law mst
        dap msh
        lac i mb1     / time involved
        cma cli-opr
        sar 3s
        dac m̄xc
ms1,    sub (140
        sma
        idx msh
mz1,    random
        and (777
        ior (scl
        dac mi1
        random
        scr 9s
        sir 9s
msh,    xct .
mi1,    hlt
        add i my1
        swap
        add i mx1
        dpy-i 300
        count m̄xc, mz1
        count i ma1, mxr
        dzm i ml1
mxr,    jmp .

mst,    scr 1s
        scr 3s

/ torpedo calc routine

tcr,    dap trc
        count i ma1, tc1
        lac (mex 400000
        dac i ml1
        law i 2
        dac i ma1
        jmp trc

tc1,    lac i mx1
        sar 9s
        xct the
        add i m̄dy
        dac i m̄dy
```

```
          sar 3s
          add i my1
          dac i my1
          sar 9s
          xct the
          add i m̅dx
          dac i m̅dx
          sar 3s
          add i mx1
          dac i mx1
          dispt i, i my1, 1
trc,      jmp .
```

```
/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,    dap hp2
        count i ma1, hp2
        law hp3            / next step
        dac i ml1
        law 7
        dac i mb1
        random
        scr 9s
        sir 9s
        xct hr1
        add i mx1
        dac i mx1
        swap
        add i my1
        dac i my1
        random
        scr 9s
        sir 9s
        xct hr2
        dac i mdy
        dio i mdx
        setup h̅pt,3
        lac ran
        dac i mth
hp4,    lac i mth
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        count h̅pt,hp4
        xct hd2
        dac i ma1
hp2,    jmp .

/ this routine handles a ship breaking out of
/ hyperspace.

hp3,    dap hp5
        count i̲ ma1,hp6
        lac i m̅h1
        dac i ml1
        law 2000
        dac i mb1̲
        count i̲ m̅h2,hp7
        dzm i m̅h2
```

```
hp7,    xct hd3
        dac i m̅h3
        lac i m̅h4
        add hur
        dac i m̅h4
        random
        ior (400000
        add i m̅h4
        spa
        jmp hp5
        lac (mex 400000
        dac i ml1
        law i 10
        dac i ma1
        law 2000
        dac i mb1
hp6,    lac i mx1
        dispt i, i my1, 2
hp5,    jmp .
```

```
/ spaceship calc

ss1,    dap srt             / first spaceship
        jsp i c̅wg
        dio s̅cw
        jmp sr0

ss2,    dap srt             / second spaceship
        jsp i c̅wg
        rir 4s
        dio s̅cw

sr0,

sc1,    lio s̅cw             /control word
        clf 6 cla-opr       /update angle
        spi
        add maa
        ril 1s
        spi
        sub maa
mom,    add .
        dac i mom
        szs 10
        jmp sr8
        dzm i mom
        ral 7s
sr8,    ril 1s
        spi
        stf 6
        lio i m̅fu
        spi i
        clf 6

mth,    add .
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        jda sin
        dac s̅n
        dzm b̅x
        dzm b̅y
        szs 60
        jmp bsg
        lac i mx1
        dac t̅1
        mul t̅1
        scr 1s
        dac a̅cx
        cla
        scr 2s
        dio i̅ox
        lac i my1
        dac t̅1
        mul t̅1
        scr 1s
        dac a̅cy
```

```
          cla
          scr 2s
          swap
          add i̅ox
          swap
          scl 2s
          add a̅cx
          add a̅cy
          sub str
          sma i sza-skp
          jmp pof
          add str
          varsft
          dac t̅1
          jda sqt
          mul t̅1
          undosft
          scr 9s
          scr 6s
          szs i 20            / switch 2 for light star
          scr 2s
          sza
          jmp bsg
          scr 1s
          dio t̅1
          integrate mx1, b̅x
          integrate my1, b̅y
bsg,      cla
          sad i mfu
          clf 6
          lac i mth
          jda cos
          dac c̅s
          sar 9s
          xct sac
          szf i 6
          cla
          add b̅y
          diff m̅dy, my1, (sar 3s
          lac s̅n
          sar 9s
          xct sac
          cma
          szf i 6
          cla
          add b̅x
          diff m̅dx, mx1, (sar 3s
sp1,      scale s̅n, 5s, s̅sn
sp2,      scale c̅s, 5s, s̅cn
          lac i mx1
```

```
        sub s̅sn
        dac s̅x1
        sub s̅sn
        dac s̅tx
        lac i my1
        add s̅cn
        dac s̅y1
        add s̅cn
        dac s̅ty
        scale s̅n, 9s, ssn
        scale c̅s, 9s, scn
        lac s̅sn
        dac s̅sm
        add s̅cn
        dac s̅sc
        dac s̅sd
        lac s̅sn
        sub s̅cn
        dac c̅sn
        cma
        dac c̅sm
        lac s̅cn
        dac s̅cm
        cla cli-opr
        dpy-4000
sp5,    jmp .
sq6,    ioh
        ranct sar 9s, sar 4s, s̅rc
        lio s̅cw
        ril 2s
        spi i                  / not blasting
        jmp sq9                / no tail
sq7,    scale s̅n, 8s, s̅sn
        scale c̅s, 8s, s̅cn
        count i mfu, st2
        dzm i mfu
        jmp sq9

st2,    yincr s̅x1, s̅y1, sub
        dispt i, s̅y1
        count s̅rc,sq7
sq9,    count i ma1, sr5   / check if torp tube reloaded
        dzm i ma1     / prevent count around
mco,    lac .                  / previous contro word
        cma
        szs i 30
        clc
        and s̅cw       / present control word
        ral 3s                 / torpedo bit to bit 0
        sma
        jmp sr5                / no launch
        count i m̅tr, st1   / check if torpedos exhausted
        dzm i m̅tr          / prevent count around
        jmp sr5
st1,    init sr1, mtb      / search for unused object
sr1,    lac .
        sza i                  / 0 if unused
        jmp sr2
        index sr1, (lac mtb nob, sr1
        hlt                    / no space for new objects
        jmp .-1
```

```
sr2,    lac (tcr            / set up torpedo calc
        dac i sr1
        law nob
        add sr1
        dap ss3
        lio stx
ss3,    dio .
        add (nob
        dap ss4
        lio sty
ss4,    dio .
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac sn
        xct tvl
        cma
        add i mdx
sr3,    dac .
        lac cs
        xct tvl
        add i mdy
sr4,    dac .
        xct rlt
        dac i ma1      / permit torp tubes to cool
trf,    xct tlf        / life of torpedo
sr6,    dac .
        law 20
sr7,    dap .               / length of torp calc.
sr5,    count i mh3, st3    / hyperbutton active?
        dzm i mh3
        lac i mh2
        sza i
        jmp st3
        lac scw
        cma
        ior i mco
        and (600000
        sza
        jmp st3
        lac i ml1
        dac i mh1
        lac (hp1 400000
        dac i ml1
        xct hd1
        dac i ma1
        law 3
        dac i mb1
st3,
~~srt~~,    jmp . -> LAC I MCO
                 LAC SCW
                 DAC I MCO

            ->   jmp .
```

```
/ here to handle spaceships dragged into star


/ spaceship in star

pof,    dzm i m̄dx
        dzm i m̄dy
        szs 50
        jmp po1
        lac (377777
        dac i mx1
        dac i my1
        lac i mb1
        dac s̄sn
        count s̄sn, .
        jmp srt

po1,    lac (mex 400000     / now go bang
        dac i ml1
        law i 10
        dac i ma1
        jmp srt
```

```
/ outlines of spaceships

ot1,    111131
        111111
        111111
        111163
        311111
        146111
        111114
        700000
. 5/

ot2,    013113
        113111
        116313
        131111
        161151
        111633
        365114
        700000
. 5/


        constants
        variables
p,      . 200/              / space for patches

mtb,                        / table of objects and their properties




start 4
```

spacewar game saver patch

```
mg1=1510
ran=31

/+ tw → punch
/- tw → read

40/
cwr,    dap cwx
        lat

cw2,    cks
        ril 1s
        spi+spa i-skp
        jmp cw1
        rrb
        rpa-i
cw3,    rir 4s
cwx,    jmp .

cw1,    ril 3s
        spi+sma i-skp
        jmp cw2
        jsp mg1
        ril 4s
        ppa-i
        jmp cw3

6000/                      /new starting address
go,     lat
        sma
        jmp pu
        rpb
        dio ran
        rpa-i
        jmp 4

pu,     law i 200
        dac p̅c̅
        cli
        ppa
        isp p̅c̅
        jmp .-2
        lio ran
        ppb          ril 6s
        ppb          ril 6s
        ppb-i
        jmp 4

variables

        start go
```

1j	6077
1q	6117
1sc	3151
2j	6121
2q	6141
2sc	3152
3j	6143
3q	6403
4j	6405
4q	7747
a	1402
a1	1374
a2	1437
a3	1470
a4	1420
a40	1377
a5	1414
a6	1431
acx	3162
acy	3164
bcc	1257
bck	746
bcx	752
bds	534
bjm	533
bkc	1260
blp	466
blx	513
bpt	514
bpx	735
bsg	2317
bx	3135
by	3136
cos	100
cs	3165
csm	3127
csn	3132
csx	146
cwg	3153
cwr	40
ddd	20
fgr	32
fid	22
fie	15
fin	6
flo	55
flp	45
foo	12
fou	14
fpo	54
fpr	1261
frr	13
fs	3
fuu	34

fx	35
fyn	17
gct	3154
grv	32
hd1	23
hd2	24
hd3	25
hp1	2001
hp2	2061
hp3	2062
hp4	2051
hp5	2123
hp6	2120
hp7	2074
hr1	26
hr2	27
hur	30
iox	3163
ma1	1610
ma2	1611
maa	13
mb1	1624
mb2	1604
mco	2466
md1	1346
mdn	1352
mdx	3140
mdy	3141
me1	16
me2	17
mex	1667
mfu	3142
mg1	1510
mg2	1514
mg3	1513
mg4	1520
mh1	3144
mh2	3145
mh3	3146
mh4	3147
mhs	22
mi1	1731
ml1	1521
ml2	1552
ml0	1262
moc	3155
mom	2143
mot	1550
mq1	1627
mq2	1612
mq3	1662
mq4	1621
ms1	1706
msh	1730

mst	1745
mt1	3156
mtb	3371
mtc	3137
mth	2157
mtr	3143
mx1	1555
mx2	1556
mxc	3157
mxr	1744
my1	1565
my2	1566
mz1	1711
na1	3501
nb1	3531
nco	3653
ndx	3561
ndy	3611
nfu	3645
nh1	3655
nh2	3657
nh3	3661
nh4	3663
nnn	3665
nob	30
nom	3641
not	3651
ntd	3150
nth	3643
ntr	3647
nx1	3421
ny1	3451
oc	230
oc1	375
oc2	420
oc3	426
oc4	434
oc5	442
oc6	450
oc9	460
occ	3123
ocd	411
oce	402
ocg	252
och	253
oci	3124
ocj	250
ock	241
ocm	373
ocn	374
oco	264
ocp	266
ocq	265
ocr	267

ocs	222
ocx	372
ocz	227
ot1	2626
ot2	2643
p	3171
po1	2621
pof	2605
ran	31
rlt	10
sac	14
sbf	61
sc1	2134
scm	3125
scn	3114
scw	3160
sft	66
si1	112
si2	147
si3	117
sin	106
sn	3161
sp1	2353
sp2	2356
sp5	2417
sq1	220
sq2	221
sq3	171
sq6	2420
sq7	2437
sq9	2463
sqt	162
sqx	174
sr1	2504
sr2	2514
sr3	2543
sr4	2547
sr5	2556
sr6	2553
sr7	2555
sr8	2151
src	3170
sr0	2134
srt	2604
ss1	2124
ss2	2130
ss3	2522
ss4	2526
ssa	3133
ssc	3131
ssd	3130
ssi	3134
ssm	3126
ssn	3113

st1	2502
st2	2451
st3	2602
str	15
stx	3166
sty	3167
sx1	3121
sy1	3122
t1	3116
t2	3117
tc1	1757
tcr	1747
the	21
tlf	11
tno	6
trc	2000
trf	2552
tvl	7
v2	3
xys	3115
xyt	3120