

Nous reproduisons ci-dessous le sous-programme en FORTRAN IV utilisé par SDP4 et SDP8. Détaillons les variables utilisées, afin d'être cohérent avec le fichier pdf SDP4.

$XMO = M_0$	$XNODEO = \Omega_0$	$OMEGAO = \omega_0$	$EO = e_0$	$XINCL = i_0$
$XNO = n_0$	$BSTAR = B^*$	$CK2 = k_2$	$CK4 = k_4$	$E6A = 10^{-6}$
$XKE = k_E$	$XJ3 = J_3$	$TOTHRD = 2/3$	$QOMS2T = (q_0 - s)^4$	
$PIO2 = \frac{\pi}{2}$	$DE2RA = \frac{\pi}{180}$	$TWOPI = 2\pi$	$X3PIO2 = \frac{3\pi}{2}$	$XKMPER = r_E$

XMNPDA = 1440

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* DEEP SPACE                                31 OCT 80
SUBROUTINE DEEP
COMMON/E1/XMO,XNODEO,OMEGAO,EO,XINCL,XNO,XNDT2O,
1 XNDD6O,BSTAR,X,Y,Z,XDOT,YDOT,ZDOT,EPOCH,DS50
COMMON/C1/CK2,CK4,E6A,QOMS2T,S,TOTHRD,
1 XJ3,XKE,XKMPER,XMNPDA,AE
COMMON/C2/DE2RA,PI,PIO2,TWOPI,X3PIO2
DOUBLE PRECISION EPOCH, DS50
DOUBLE PRECISION
* DAY,PREEP,XNODCE,ATIME,DELT,SAVTSN,STEP2,STEPN,STEPP
DATA ZNS, C1SS, ZES/
A 1.19459E-5, 2.9864797E-6, .01675/
DATA ZNL, C1L, ZEL/
A 1.5835218E-4, 4.7968065E-7, .05490/
DATA ZCOSIS, ZSINIS, ZSINGS/
A .91744867, .39785416, -.98088458/
DATA ZCOSGS, ZCOSHS, ZSINHS/
A .1945905, 1.0, 0.0/
DATA Q22,Q31,Q33/1.7891679E-6,2.1460748E-6,2.2123015E-7/
DATA G22,G32/5.7686396,0.95240898/
DATA G44,G52/1.8014998,1.0508330/
DATA G54/4.4108898/
DATA ROOT22,ROOT32/1.7891679E-6,3.7393792E-7/
DATA ROOT44,ROOT52/7.3636953E-9,1.1428639E-7/
DATA ROOT54/2.1765803E-9/
DATA THDT/4.3752691E-3/
* ENTRANCE FOR DEEP SPACE INITIALIZATION
ENTRY DPINIT(EQSQ,SINIQ,COSIQ,RTEQSQ,AO,COSQ2,SINOMO,COSOMO,
1 BSQ,XLLDOT,OMGDT,XNODOT,XNODP)
THGR=THETAG(JJ0)
EQ = EO
XNQ = XNODP
AQNV = 1./AO
XQNCL = XINCL
XMAO=XMO
XPIDOT=OMGDT+XNODOT
SINQ = SIN(XNODEO)
COSQ = COS(XNODEO)
OMEGAQ = OMEGAO
* INITIALIZE LUNAR SOLAR TERMS
5 DAY=DS50+18261.5D0

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IF (DAY.EQ.PREEP) GO TO 10
PREEP = DAY
XNODCE=4.5236020-9.2422029E-4*DAY
59
STEM=DSIN (XNODCE)
CTEM=DCOS (XNODCE)
ZCOSIL=.91375164-.03568096*CTEM
ZSINIL=SQRT (1.-ZCOSIL*ZCOSIL)
ZSINHL= .089683511*STEM/ZSINIL
ZCOSHL=SQRT (1.-ZSINHL*ZSINHL)
C=4.7199672+.22997150*DAY
GAM=5.8351514+.0019443680*DAY
ZMOL = FMOD2P (C-GAM)
ZX= .39785416*STEM/ZSINIL
ZY= ZCOSHL*CTEM+0.91744867*ZSINHL*STEM
ZX=ACTAN (ZX,ZY)
ZX=GAM+ZX-XNODCE
ZCOSGL=COS (ZX)
ZSINGL=SIN (ZX)
ZMOS=6.2565837D0+.017201977D0*DAY
ZMOS=FMOD2P (ZMOS)
* DO SOLAR TERMS
10 LS = 0
SAVTSN=1.D20
ZCOSG=ZCOSGS
ZSING=ZSINGS
ZCOSI=ZCOSIS
ZSINI=ZSINIS
ZCOSH=COSQ
ZSINH=SINQ
CC=C1SS
ZN=ZNS
ZE=ZES
ZMO=ZMOS
XNOI=1./XNQ
ASSIGN 30 TO LS
20 A1=ZCOSG*ZCOSH+ZSING*ZCOSI*ZSINH
A3=-ZSING*ZCOSH+ZCOSG*ZCOSI*ZSINH
A7=-ZCOSG*ZSINH+ZSING*ZCOSI*ZCOSH
A8=ZSING*ZSINI
A9=ZSING*ZSINH+ZCOSG*ZCOSI*ZCOSH
A10=ZCOSG*ZSINI
A2= COSIQ*A7+ SINIQ*A8
A4= COSIQ*A9+ SINIQ*A10
A5=- SINIQ*A7+ COSIQ*A8
A6=- SINIQ*A9+ COSIQ*A10
C
X1=A1*COSOMO+A2*SINOMO
X2=A3*COSOMO+A4*SINOMO
X3=-A1*SINOMO+A2*COSOMO
60
X4=-A3*SINOMO+A4*COSOMO
X5=A5*SINOMO
X6=A6*SINOMO
X7=A5*COSOMO
X8=A6*COSOMO
C

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Z31=12.*X1*X1-3.*X3*X3
Z32=24.*X1*X2-6.*X3*X4
Z33=12.*X2*X2-3.*X4*X4
Z1=3.*(A1*A1+A2*A2)+Z31*EQSQ
Z2=6.*(A1*A3+A2*A4)+Z32*EQSQ
Z3=3.*(A3*A3+A4*A4)+Z33*EQSQ
Z11=-6.*A1*A5+EQSQ*(-24.*X1*X7-6.*X3*X5)
Z12=-6.*(A1*A6+A3*A5)+EQSQ*(-24.*(X2*X7+X1*X8)-6.*(X3*X6+X4*X5))
Z13=-6.*A3*A6+EQSQ*(-24.*X2*X8-6.*X4*X6)
Z21=6.*A2*A5+EQSQ*(24.*X1*X5-6.*X3*X7)
Z22=6.*(A4*A5+A2*A6)+EQSQ*(24.*(X2*X5+X1*X6)-6.*(X4*X7+X3*X8))
Z23=6.*A4*A6+EQSQ*(24.*X2*X6-6.*X4*X8)
Z1=Z1+Z1+BSQ*Z31
Z2=Z2+Z2+BSQ*Z32
Z3=Z3+Z3+BSQ*Z33
S3=CC*XNOI
S2=-.5*S3/RTEQSQ
S4=S3*RTEQSQ
S1=-15.*EQ*S4
S5=X1*X3+X2*X4
S6=X2*X3+X1*X4
S7=X2*X4-X1*X3
SE=S1*ZN*S5
SI=S2*ZN*(Z11+Z13)
SL=-ZN*S3*(Z1+Z3-14.-6.*EQSQ)
SGH=S4*ZN*(Z31+Z33-6.)
SH=-ZN*S2*(Z21+Z23)
IF(XQNCL.LT.5.2359877E-2) SH=0.0
EE2=2.*S1*S6
E3=2.*S1*S7
XI2=2.*S2*Z12
XI3=2.*S2*(Z13-Z11)
XL2=-2.*S3*Z2
XL3=-2.*S3*(Z3-Z1)
XL4=-2.*S3*(-21.-9.*EQSQ)*ZE
XGH2=2.*S4*Z32
XGH3=2.*S4*(Z33-Z31)
XGH4=-18.*S4*ZE
XH2=-2.*S2*Z22
XH3=-2.*S2*(Z23-Z21)
GO TO LS
61
* DO LUNAR TERMS
30 SSE = SE
SSI=SI
SSL=SL
SSH=SH/SINIQ
SSG=SGH-COSIQ*SSH
SE2=EE2
SI2=XI2
SL2=XL2
SGH2=XGH2
SH2=XH2
SE3=E3
SI3=XI3
SL3=XL3
SGH3=XGH3

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SH3=XH3
SL4=XL4
SGH4=XGH4
LS=1
ZCOSG=ZCOSGL
ZSING=ZSINGL
ZCOSI=ZCOSIL
ZSINI=ZSINIL
ZCOSH=ZCOSHL*COSQ+ZSINHL*SINQ
ZSINH=SINQ*ZCOSHL-COSQ*ZSINHL
ZN=ZNL
CC=C1L
ZE=ZEL
ZMO=ZMOL
ASSIGN 40 TO LS
GO TO 20
40 SSE = SSE+SE
SSI=SSI+SI
SSL=SSL+SL
SSG=SSG+SGH-COSIQ/SINI*SH
SSH=SSH+SH/SINI
* GEOPOTENTIAL RESONANCE INITIALIZATION FOR 12 HOUR ORBITS
IRESFL=0
ISYNFL=0
IF (XNQ.LT. (.0052359877) .AND. XNQ.GT. (.0034906585)) GO TO 70
IF (XNQ.LT. (8.26E-3) .OR. XNQ.GT. (9.24E-3)) RETURN
IF (EQ.LT.0.5) RETURN
IRESFL =1
EOC=EQ*EQSQ
G201=-.306-(EQ-.64)*.440
62
IF (EQ.GT. (.65)) GO TO 45
G211=3.616-13.247*EQ+16.290*EQSQ
G310=-19.302+117.390*EQ-228.419*EQSQ+156.591*EOC
G322=-18.9068+109.7927*EQ-214.6334*EQSQ+146.5816*EOC
G410=-41.122+242.694*EQ-471.094*EQSQ+313.953*EOC
G422=-146.407+841.880*EQ-1629.014*EQSQ+1083.435*EOC
G520=-532.114+3017.977*EQ-5740*EQSQ+3708.276*EOC
GO TO 55
45 G211=-72.099+331.819*EQ-508.738*EQSQ+266.724*EOC
G310=-346.844+1582.851*EQ-2415.925*EQSQ+1246.113*EOC
G322=-342.585+1554.908*EQ-2366.899*EQSQ+1215.972*EOC
G410=-1052.797+4758.686*EQ-7193.992*EQSQ+3651.957*EOC
G422=-3581.69+16178.11*EQ-24462.77*EQSQ+12422.52*EOC
IF (EQ.GT. (.715)) GO TO 50
G520=1464.74-4664.75*EQ+3763.64*EQSQ
GO TO 55
50 G520=-5149.66+29936.92*EQ-54087.36*EQSQ+31324.56*EOC
55 IF (EQ.GE. (.7)) GO TO 60
G533=-919.2277+4988.61*EQ-9064.77*EQSQ+5542.21*EOC
G521 = -822.71072+4568.6173*EQ-8491.4146*EQSQ+5337.524*EOC
G532 = -853.666+4690.25*EQ-8624.77*EQSQ+5341.4*EOC
GO TO 65
60 G533=-37995.78+161616.52*EQ-229838.2*EQSQ+109377.94*EOC
G521 = -51752.104+218913.95*EQ-309468.16*EQSQ+146349.42*EOC
G532 = -40023.88+170470.89*EQ-242699.48*EQSQ+115605.82*EOC
65 SINI2=SINI*SQ

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F220=.75*(1.+2.*COSIQ+COSQ2)
F221=1.5*SINI2
F321=1.875*SINIQ*(1.-2.*COSIQ-3.*COSQ2)
F322=-1.875*SINIQ*(1.+2.*COSIQ-3.*COSQ2)
F441=35.*SINI2*F220
F442=39.3750*SINI2*SINI2
F522=9.84375*SINIQ*(SINI2*(1.-2.*COSIQ-5.*COSQ2)
1+.33333333*(-2.+4.*COSIQ+6.*COSQ2))
F523 = SINIQ*(4.92187512*SINI2*(-2.-4.*COSIQ+10.*COSQ2)
*+6.56250012*(1.+2.*COSIQ-3.*COSQ2))
F542 = 29.53125*SINIQ*(2.-8.*COSIQ+COSQ2*(-12.+8.*COSIQ
*+10.*COSQ2))
F543=29.53125*SINIQ*(-2.-8.*COSIQ+COSQ2*(12.+8.*COSIQ-10.*COSQ2))
XNO2=XNQ*XNQ
AINV2=AQNV*AQNV
TEMP1 = 3.*XNO2*AINV2
TEMP = TEMP1*ROOT22
D2201 = TEMP*F220*G201
D2211 = TEMP*F221*G211
TEMP1 = TEMP1*AQNV
TEMP = TEMP1*ROOT32
D3210 = TEMP*F321*G310
63
D3222 = TEMP*F322*G322
TEMP1 = TEMP1*AQNV
TEMP = 2.*TEMP1*ROOT44
D4410 = TEMP*F441*G410
D4422 = TEMP*F442*G422
TEMP1 = TEMP1*AQNV
TEMP = TEMP1*ROOT52
D5220 = TEMP*F522*G520
D5232 = TEMP*F523*G532
TEMP = 2.*TEMP1*ROOT54
D5421 = TEMP*F542*G521
D5433 = TEMP*F543*G533
XLAMO = XMAO+XNODEO+XNODEO-THGR-THGR
BFACT = XLLODOT+XNODOT+XNODOT-THDT-THDT
BFACT=BFACT+SSL+SSH+SSH
GO TO 80
* SYNCHRONOUS RESONANCE TERMS INITIALIZATION
70 IRESFL=1
ISYNFL=1
G200=1.0+EQSQ*(-2.5+.8125*EQSQ)
G310=1.0+2.0*EQSQ
G300=1.0+EQSQ*(-6.0+6.60937*EQSQ)
F220=.75*(1.+COSIQ)*(1.+COSIQ)
F311=.9375*SINIQ*SINIQ*(1.+3.*COSIQ)-.75*(1.+COSIQ)
F330=1.+COSIQ
F330=1.875*F330*F330*F330
DEL1=3.*XNQ*XNQ*AQNV*AQNV
DEL2=2.*DEL1*F220*G200*Q22
DEL3=3.*DEL1*F330*G300*Q33*AQNV
DEL1=DEL1*F311*G310*Q31*AQNV
FASX2=.13130908
FASX4=2.8843198
FASX6=.37448087
XLAMO=XMAO+XNODEO+OMEGAO-THGR

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BFACT = XLLDOT+XPIDOT-THDT
BFACT=BFACT+SSL+SSG+SSH
80 XFACT=BFACT-XNQ
C
C INITIALIZE INTEGRATOR
C
XLI=XLAMO
XNI=XNQ
ATIME=0.D0
STEPP=720.D0
STEPN=-720.D0
STEP2 = 259200.D0
64
RETURN
* ENTRANCE FOR DEEP SPACE SECULAR EFFECTS
ENTRY DPSEC (XLL,OMGASM,XNODES,EM,XINC,XN,T)
XLL=XLL+SSL*T
OMGASM=OMGASM+SSG*T
XNODES=XNODES+SSH*T
EM=EO+SSE*T
XINC=XINCL+SSI*T
IF(XINC .GE. 0.) GO TO 90
XINC = -XINC
XNODES = XNODES + PI
OMGASM = OMGASM - PI
90 IF(IRESFL .EQ. 0) RETURN
100 IF (ATIME.EQ.0.D0) GO TO 170
IF(T.GE.(0.D0).AND.ATIME.LT.(0.D0)) GO TO 170
IF(T.LT.(0.D0).AND.ATIME.GE.(0.D0)) GO TO 170
105 IF(DABS(T).GE.DABS(ATIME)) GO TO 120
DELT=STEPP
IF (T.GE.0.D0) DELT = STEPN
110 ASSIGN 100 TO IRET
GO TO 160
120 DELT=STEPN
IF (T.GT.0.D0) DELT = STEPP
125 IF (DABS(T-ATIME).LT.STEPP) GO TO 130
ASSIGN 125 TO IRET
GO TO 160
130 FT = T-ATIME
ASSIGN 140 TO IRETN
GO TO 150
140 XN = XNI+XNDOT*FT+XNDDT*FT*FT*0.5
XL = XLI+XLDOT*FT+XNDOT*FT*FT*0.5
TEMP = -XNODES+THGR+T*THDT
XLL = XL-OMGASM+TEMP
IF (ISYNFL.EQ.0) XLL = XL+TEMP+TEMP
RETURN
C
C DOT TERMS CALCULATED
C
150 IF (ISYNFL.EQ.0) GO TO 152
XNDOT=DEL1*SIN (XLI-FASX2)+DEL2*SIN (2.*(XLI-FASX4))
1 +DEL3*SIN (3.*(XLI-FASX6))
XNDDT = DEL1*COS(XLI-FASX2)
* +2.*DEL2*COS(2.*(XLI-FASX4))
* +3.*DEL3*COS(3.*(XLI-FASX6))

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GO TO 154
152 XOMI = OMEGAQ+OMGDT*ATIME
65
X2OMI = XOMI+XOMI
X2LI = XLI+XLI
XNDOT = D2201*SIN(X2OMI+XLI-G22)
* +D2211*SIN(XLI-G22)
* +D3210*SIN(XOMI+XLI-G32)
* +D3222*SIN(-XOMI+XLI-G32)
* +D4410*SIN(X2OMI+X2LI-G44)
* +D4422*SIN(X2LI-G44)
* +D5220*SIN(XOMI+XLI-G52)
* +D5232*SIN(-XOMI+XLI-G52)
* +D5421*SIN(XOMI+X2LI-G54)
* +D5433*SIN(-XOMI+X2LI-G54)
XNDDT = D2201*COS(X2OMI+XLI-G22)
* +D2211*COS(XLI-G22)
* +D3210*COS(XOMI+XLI-G32)
* +D3222*COS(-XOMI+XLI-G32)
* +D5220*COS(XOMI+XLI-G52)
* +D5232*COS(-XOMI+XLI-G52)
* +2.*(D4410*COS(X2OMI+X2LI-G44)
* +D4422*COS(X2LI-G44)
* +D5421*COS(XOMI+X2LI-G54)
* +D5433*COS(-XOMI+X2LI-G54))
154 XLDOT=XNI+XFACT
XNDDT = XNDDT*XLDOT
GO TO IRETN
C
C INTEGRATOR
C
160 ASSIGN 165 TO IRETN
GO TO 150
165 XLI = XLI+XLDOT*DELT+XNDOT*STEP2
XNI = XNI+XNDOT*DELT+XNDDT*STEP2
ATIME=ATIME+DELT
GO TO IRET
C
C EPOCH RESTART
C
170 IF (T.GE.0.D0) GO TO 175
DELT=STEPN
GO TO 180
175 DELT = STEPP
180 ATIME = 0.D0
XNI=XNQ
XLI=XLAMO
GO TO 125
C
C ENTRANCES FOR LUNAR-SOLAR PERIODICS
C
66
C
ENTRY DPPER(EM,XINC,OMGASM,XNODES,XLL)
SINIS = SIN(XINC)
COSIS = COS(XINC)
IF (DABS(SAVTSN-T).LT.(30.D0)) GO TO 210

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SAVTSN=T
ZM=ZMOS+ZNS*T
205 ZF=ZM+2.*ZES*SIN (ZM)
SINZF=SIN (ZF)
F2=.5*SINZF*SINZF-.25
F3=-.5*SINZF*COS (ZF)
SES=SE2*F2+SE3*F3
SIS=SI2*F2+SI3*F3
SLS=SL2*F2+SL3*F3+SL4*SINZF
SGHS=SGH2*F2+SGH3*F3+SGH4*SINZF
SHS=SH2*F2+SH3*F3
ZM=ZMOL+ZNL*T
ZF=ZM+2.*ZEL*SIN (ZM)
SINZF=SIN (ZF)
F2=.5*SINZF*SINZF-.25
F3=-.5*SINZF*COS (ZF)
SEL=EE2*F2+E3*F3
SIL=XI2*F2+XI3*F3
SLL=XL2*F2+XL3*F3+XL4*SINZF
SGHL=XGH2*F2+XGH3*F3+XGH4*SINZF
SHL=XH2*F2+XH3*F3
PE=SES+SEL
PINC=SIS+SIL
PL=SLS+SLL
210 PGH=SGHS+SGHL
PH=SHS+SHL
XINC = XINC+PINC
EM = EM+PE
IF(XQNCL.LT.(.2)) GO TO 220
GO TO 218
C
C APPLY PERIODICS DIRECTLY
C
218 PH=PH/SINIQ
PGH=PGH-COSIQ*PH
OMGASM=OMGASM+PGH
XNODES=XNODES+PH
XLL = XLL+PL
GO TO 230
C
C APPLY PERIODICS WITH LYDDANE MODIFICATION
C
220 SINOK=SIN(XNODES)
67
COSOK=COS(XNODES)
ALFDP=SINIS*SINOK
BETDP=SINIS*COSOK
DALF=PH*COSOK+PINC*COSIS*SINOK
DBET=-PH*SINOK+PINC*COSIS*COSOK
ALFDP=ALFDP+DALF
BETDP=BETDP+DBET
XLS = XLL+OMGASM+COSIS*XNODES
DLS=PL+PGH-PINC*XNODES*SINIS
XLS=XLS+DLS
XNODES=ACTAN(ALFDP,BETDP)
XLL = XLL+PL
OMGASM = XLS-XLL-COS(XINC)*XNODES

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230 CONTINUE
RETURN
END

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Nous donnons également la fonction thetag :

```

FUNCTION THETAG(XJ0)
TU = (XJ0 - 2451545.0) / 36525.0
TS0 = 280.46061837 + 360.98564736629 * (XJ0 - 2451545.0) + 0.000387933 * TU *
TU - TU * TU * TU / 38710000.0
THETAG = MOD2PI(TS0 * DE2RA)
DS50 = XJ0 - 2433281.5
RETURN
END

```

ainsi que la fonction arctangente et modulo 2π :

```

FUNCTION ACTAN(SINX,COSX)
COMMON/C2/DE2RA,PI,PIO2,TWOPI,X3PIO2
ACTAN=0.
IF (COSX.EQ.0. ) GO TO 5
IF (COSX.GT.0. ) GO TO 1
ACTAN=PI
GO TO 7
1 IF (SINX.EQ.0. ) GO TO 8
IF (SINX.GT.0. ) GO TO 7
ACTAN=TWOPI
GO TO 7
5 IF (SINX.EQ.0. ) GO TO 8
IF (SINX.GT.0. ) GO TO 6
ACTAN=X3PIO2
GO TO 8
6 ACTAN=PIO2
GO TO 8
7 TEMP=SINX/COSX
ACTAN=ACTAN+ATAN(TEMP)
8 RETURN
END

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```

FUNCTION FMOD2P(X)
COMMON/C2/DE2RA,PI,PIO2,TWOPI,X3PIO2
FMOD2P=X
I=FMOD2P/TWOPI
FMOD2P=FMOD2P-I*TWOPI
IF (FMOD2P.LT.0) FMOD2P=FMOD2P+TWOPI
RETURN
END

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