Symbol Index for Solar Sailing by Colin R. McInnes
SymbolIndexMcInnes.docx 2016 March

pxxy means
page xx
y = t top of page
y = m middle of page
y = b bottom of page

In equations "a" sometimes looks like a truncated "d".
A p13b p73m p116t,p285b area of sail, usually in m^2,often normal to Sol, p58T.
p35b area normal to energy propagation
p93b area of solar thruster
A p88b component of cyclic pitch
p119b aphelion in fig.4.7.
a p39m sail acceleration
a p174m,p198t radiation pressure acceleration, eq.5.2a, eq.5.65a.
au p13b astronomical unit 149.598E9 m
a_0 p14t,p58t,p134m characteristic acceleration of a sail at one au. $a_0 = 2\eta P/\sigma$. See also κ.
p39b note that α = 0. $a_0 = (9.12\eta/\sigma)$ mm/s^2 if σ is in g/m^2
p40t Add to text: $a_0 = 9.12/\sigma^* = 5.961\ \beta\eta$
a_0 p162t Initial value of semi-major axis a.
a p47b absorption coefficient
a p67t hole size of perforated film.
a p119b,122t,153t semi-major axis fig.4.7, 1/2 dist *P* to *A*. $a = (r_A+r_P)/2$.
Δa p1.53m,p1.55m,p1.58t,p160b Change in semi-major axis *a* per orbit.
a p195m aphelion of Keplerian orbit, not displaced circular orbit.
a p272b acceleration.
$\tilde{a}$ p273m thermally limited acceleration.
a_ρ, a_z p208t accelerations in *ρ* and *z* directions?
B p36m magnetic field
B p88b component of cyclic pitch
B_f p48m non-Lambertian reflection coefficient, front of sail.
B_b p48b non-Lambertian reflection coefficient, back of sail.
b p67t size of film between holes of perforated sail
C p35t,p84m chord width of heliogyro blade
C p113b center of mass of Sol-sail system.
C_1, C_2, C_3, C_4 pp205m,206m,202b,206b for definitions. The dashed lines in figs.5.14-5.16.
c p35t,p83b speed of light
c_1, c_2, c_3 p53m parameters for billowing sail
c p67t not sure hwy this is in diagram.
D p75m total length of spars for polygonal sail
D_C p73m circumference of disc sail with radius R
D_i p167b i = 1,2,3,4 constants of motion.
D_S p73m totl length of four diagonal spars for square sail
D p273b Fresnal zone lens diameter.
d p36b take differential
p81t distance of control vane from origin, fig. 3.13.
d p273b sail diameter.
$\mathbf{d}_i$ p81t vane location relative to center of mass, including payload
d_s p273b laser beam spot diameter.
E p35t Energy
p122t,p157m Energy per unit mass.
E p279m laser energy (per unit mass?).
E p286b Kinetic energy of impinging particle, usually hydrogen.
E′ p279m laser energy in moving system.
$\tilde{E}$ p2286b Kinetic energy of impinging particle after passing thru sail.
E p36m electric field
E_i p167b i = 1,2,3,4 constants of motion.

E# my usage for $10^{\#}$
E_R p274m Energy expended by rocket.
e p42t base of natural logs.
e p119b,125b eccentricity in fig.4.7. For conic $(x/a)^2 + (y/b)^2 = 1$
$e = c/a = -1 + r_p v_p^2/\mu$, etc. $e = (r_A - r_P)/(r_{A+} r_P)$.
$\mathbf{e_1}$, $\mathbf{e_2}$, $\mathbf{e_3}$ p77b Unit vectors for fig. 3.13. $\mathbf{e_3} = -\mathbf{n}$
F(**r**;t) p42m energy flux
F(r) p45m deviation of pressure of an extended source from P*,
the point source pressure. F(r) = P(r)/P*(r)
F_1, F_2 p167 assorted functions.
f p36m, p38b, force
$\mathbf{f_a}$ p47m from absorption (same as $\mathbf{f_i}$ p36m)
$\mathbf{f_e}$ p47m force from emission by re-radiation.
$\mathbf{f_i}$ p36m force from incident light,
$\mathbf{f_r}$ p36m, 47m force from reflected light
p47m forces: ,
p78m force on sail along **n**
p117 net force on perfect sail fig.4.4.
$\mathbf{f_{rs}}$ p48m force in direction **s**, fig.2.7.
$\mathbf{f_{ru}}$ p48m force in direction **n**, fig.2.7.
$\mathbf{f_n}$ p49b force in direction **n**, fig.2.7.
$\mathbf{f_t}$ p49b force in direction **t**, transverse to **n**, fig.2.7.
$\mathbf{f_0}$ p53b force for billowing sail normal to Solar radius. θ = 0.
f p137t force vector, hwile *f* is true anomaly.
f p119b true anomaly fig4.7, etc.
f p152b,p162t Fig..4.26. Angle around Terra from down-Sol line to sail.
f p279t light pressure force.
f(α) p133m part of eq.4.49.
f_0 p162t Initial angle of *f* p.157 fig.4.30.
f_1 f_2 f_i f_r p93t various forces for photon thruster
õf_S p78m force on sail perpendicular to Sol
f_r p84b radial centripetal force density of heliogyro blade
f_V p81t force on vane hwen it is perpendicular to Sol
f_x p84b chordwise centripetal force density of heliogyro blade
f_q p116t force in arbitrary direction q.
f_λ p137m force component in direction λ.
G p40t Newton's constant *G* = 6.6726 E-11 $m^3/(s^2 kg)$. see μ.
g p17b Terra's standard gravity, 9.81 m/s^2.
g p14m,p39m grams
g_i p209b gain coefficients.
gI_{SP} p248t May be same as exhaust velocity.
H p148b Hamiltonian, non-standard
p66b Hamiltonian, standard, $H \equiv T + V$.
h p35t Planck's constant
h p83b thickness of heliogyro blade
p121b orbital angular momentum per unit mass.
I p86b moment of inertia of heliogyro blade in cross section.
$I = C^3 h/12$
I p113b Inertial reference frame. See fig. 4.1.
I' p114m Inertial reference frame at C fig 4.1.
I_{sp} p17,p248t specific impulse of rocket. Change in momentum divided
by change in weight on Terra, or Δmv/Δmg. Measured in seconds.
Sloppy. Better use is change in momentum divided by change in
mass, units of (exhaust) velocity.
I_ν(**r**,**u**;t) p40b specific intensity of light
I_0 p44m frequency integrated specific intensity. $I_0 = L_S/4\pi^2 R_S^2$
I_C p74t moment of inertia of disc sail circumference sail boom
I_S p74t moment of inertia of square sail booms
IR p67t infra-red
i p119b inclination of orbit WRT ecliptic plane fig.4.7.
i p221b root(-1)
J p36m Joules
j p36m electric current

K p62t degrees Kelvin
K p207b control matrix, used for both pitch and area. Confusing.
k p42t Boltzman's constant
k p202b defines an axis for skewed (my word) Type III planetary orbit.
kg kilograms
L p73m side of square sail
L_S p35b Solar luminosity
l or script ℓ p67t IR antenna length. This should be made consistent.
l p151m unit vector from Sol hwen **r** is referenced from planet.
p197b same as above. Note that it is almost parallel to z-axis.
Δl p37m thickness
script l p77b length of articulating boom. Is "articulating" the proper word?
M p78b torque on perfect sail with off center payload
p79t components M_x M_y M_z of **M**
M p113b mass of Sol
M_S p40t mass of Sol 1.989 E30 kg
$\mathbf{M}_i$ p81t control torque
M_x M_y M_z components of $\mathbf{M}_i$
M_0 p88m torque to twist root of heliogyro blade
M p120m mean anomaly $M = n(t-\tau)$
M Chapter 5. Assorted matrices, not sure.
m p49b unit vector in direction of total force, fig. 2.7.
m p14b,p36m meters
m p14t, p113b mass of sail, structure, and payload in kg.
p58t $m = m_S + m_P$ total mass (sail+structure)+payload
m dot p274m propellant mass flow.
m_0 p35t rest mass of a body.
m_0 p274m initial mass of rocket.
m_1 p17b mass at time one.
m_2 p17b mass at time two.
m_f p174m final mass of rocket.
m_H p286t rest mass of hydrogen.
m_P p58t p77m mass of sail payload
m_p p54t mass of proton
m_S p58t p78m mass of sail and support structure
mm p14m,p39b millimeters
N p13b,p36t,p61b Newtons
N p41m number of photons
N,N' p119b ascending and descending nodes fig. 4.7.
N p74b number of spars of length R on polygonal sail
n p38b,p151m,p174m(fig.5.1),p197b unit vector normal to sail
p79b unit vector normal to control vanes, specifically
p93t unit vector along line of net force
$\mathbf{n}_1$, $\mathbf{n}_2$ p79b fig. 3.13 normals to tip vanes
n p120m mean motion $n = \sqrt{(\mu/a^3)}$.
n dot p286t rate hydrogen atoms hit sail. Hwich reference frame?
n p225b number density of hydrogen atoms in sail frame of reference.
n_0 p225b number density of hydrogen atoms in interstellar space.
O p44m Big Oh, order of magnitude
P p13b,p58t Pressure of sunlight. At one au P = 4.56 E-6 N/m^2
p36t double for reflecting surface P = 9.12 E-6 N/m^2
p36t p90m Pressure on a surface
p94m p116t solar radiation pressure
P p119b perihelion in fig.4.7.
P p272b Laser output power.
P p286m back pressure on sail from impacting hydrogen atoms.
P' p279m Laser power as seen in moving frame.
P(**r**;t) p42b radiation pressure tensor
P(r) p43b radiation from an extended uniformly bright source
P*(r) p44b radiation pressure from a point source, or a distant
extended source. $P^*(r) = L_S/2c\pi r^2$
P_w p54t Pressure of solar wind $\doteq$ 3E-9 $N/m^2 \doteq P$
P_n p85m photon pressure normal to heliogryo blade

$\boldsymbol{P}, P_{ij}$ p192   Matrix and components, not understood.
õP p273m Maximum laser power.
p   p35t,p41b   momentum   **p** = (hν/c)**u** for photons
p^ p115t reference direction perpendicular to orbital plane.
p p35t   momentum
    p119m semi-latus rectum, $p = a(1-e^2)$. (p=r if e=0)
p_ξ p_η p_θ p166m conjugate momenta
$\mathbf{p}_r$ p148b co-state for position
$\mathbf{p}_v$ p148b co-state for velocity, aka primer vector, optimum direction
        of sail force vector. Huh?
Q dot p286t energy flux. Per unit mass?
q   p115m unit vector along hwich to maximize force.
R   p113b position vector to center of mass of Sol-sail fig. 4.1.
R   p18t payload mass fraction R = (m_2/m_1)
R p73m p90m radius of disc sail
R p74b length of spar on polygonal sail
R p83b blade length of heliogyro
    p124b and following. R = 1 au., confusing notation. Use R_T or R_C.
R p175t ratio of rocket energy to light sail energy.
R_E p35b,p49m,p63m Sol-Terra distance ≡ 1 au. I use r_T. 149.598E9 m

R_S p44t Solar radius
R_T
R_i p248t mass ratios.
r p35b,p63m distance from Sol
r p84b distance along heliogyro blade
r p125b aphelion of transfer orbit, and radius of target circular orbit.
        Confusing, better would be r_A.
    p90m radial distance on a disc sail.
    p118t radial distance from Sol.
    p119b radial distance from Sol fig.4.7.
r 165b distance from Sol, here distance of planet from sol. Question :
        $r = \sqrt{(x^2 + y^2 + z^2)} = (\xi^2 + \eta^2)/2$?
r 173b distance from Sol, fig.5.1.
r_A p125b I would use this instead of r for aphelion of transfer orbit.
r_0 p131t radius of original circular orbit.
    p199b Orbit chosen for its period, $r_0 = 30\ r_{planet}$ p199b.
r   p113b vector from Sol to sail fig. 4.1.
r   p151m vector from Terra to sail fig. 4.1.
r^ p39b unit vector radial from Sol, often = $\mathbf{u_i}$. ^ should be atop **r**.
    p113b unit vector from Sol to sail fig. 4.1.
õr p47b,p63m,p272b r tilda. reflection coefficient r.
$\mathbf{r_p}$ p77b payload position vector on movable boom
$\mathbf{r_C}$ p78m Center of mass position vector of sail with moveable payload.
$\mathbf{r_1}, \mathbf{r_2}$ p113b position vectors of Sol and sail in fig. 4.1.
õr p225t reflection co-efficient.
S   p78m Sol line vector, usually called **u**.
S p120m radial force per unit mass.
    p166b Hamilton-Jacobi function. Oh,sure.
    p274t distance from laser (and ~ lens) to sail.
$S(\rho,z)$ p177b limiting surface for Type I orbits.
s   p14b,p36m seconds
s   p48m another specular reflection coefficient, those into direction **s**.
s   p47b unit vector of specularly reflected light.
s p128m linear distance
s p173b distance to interstellar sail.
õs p274t maximum sail distance for full laser acceleration.
s_0 p276m initial distance hwere laser acceleration starts.
T p18m mission duration
    p42t black body temperature of sol
    p48b,p63m sail temperature
    p90m radial tension in a disc sail film, including rotation. N/m
    p120m,p153m transverse (tangential) force per unit mass.

p122t, 173m, 175b orbital period
p134mb Transfer time in days
p165b kinetic energy per unit mass
T p199t Orbital period, $T = 2\pi/\omega$.
T p273m Sail equilibrium temperature.
$\bar{T}$ p163b Transverse acceleration averaged over one orbit.
$\tilde{T}$ p273m Maximum allowed sail temperature.
T_0 p90m tension on rim of disc sail from membrane, not counting centripetal force. N/m of rim
T_S p126m Half orbit transit time for solar sail.
T_H p126m Half orbit transit time for Hohmann orbit.
T_1 p212b Curve, fig.5.22.
T_2 p213b Curve, fig.5.22.
$t, \Delta t$ p35b,120m time
$\tilde{t}$ p278t time needed to reach diffraction limit.
t p47b unit vector normal to **n**.
t_θ p86b twisting moment of heliogryo blade from photon pressure.
t_0 p133m time at start of logarithmic orbit.
UV p61b ultra-violet
U p37m energy density
U p174b,p198m modified potential $U \equiv V + \Phi$.
u p40b p47b unit vector in direction of Sol's light
$\mathbf{u_f}$ p39b unit vector of reflected light
$\mathbf{u_i}$ p39b p93t unit vector of incident light, often **r^**, or **u**
$\mathbf{u_r}$ **p38b**p93t unit vector of reflected light
u p274m rocket exhaust speed.
V p165b potential energy per unit mass. Note κ, extra.
V p174m,p198t potential energy per unit mass for standard gravity field.
Eqs.5.2b,2.24.,eq.5.65b.
$-\Delta V$ p174m gravitational acceleration.
Δv p17b change in velocity
v p17,p122t,p128m velocity
$v(r)$ p131b velocity of solar sail.
v_w p54 velocity of solar wind =˙ 700 km/s
v_r p131b radial velocity of solar sail.
v_θ p131m transverse velocity of solar sail. `
v_E p131m circular speed of Terra.
v_M p131m circular speed of Mars.
v_0 p131m Speed of sail at start of logarithmic orbit, Terra to Mars.
p276m Speed of sail hwere laser acceleration starts.
v_∞ p276b Terminal speed of light sail.
v_{-f} p131m Speed of sail at end of logarithmic orbit, Terra to Mars.
v^μ p279t velocity four vector. ?
Δv_S p126b Impulse needed to go from Hohmann to circular orbit.
Δv_H p126b Total impulse needed from circular to circular orbit
via Hohmann transfer.
Δv p126b generalized total impulse for changing circular orbits.
Δv_1 p134m,p136t Impulse to go from Terra circular to logarithmic spiral.
Δv_2 p134m,p136t Impulse to go from logarithmic spiral to Mars circular.
Δv_T p134m Total of Δv_1 and Δv_2.
W p35b energy flux. p49m solar flux
p120m orbit normal force per unit mass.
W_E p35bp63m (Solar) energy flux at 1 AU
p36m = 1368 J/s/m^2
w p85m vertical deflection of heliogyro blade Confuses with p86b
w p86b $w \equiv \theta x$, not italic theta Confuses with p85m. Or
perhaps these are the same if w is a function of both x (chord)
and r (distance from root).
p90m displacement of a disc sail out of its plane
x p84b distance across chord from centerline of heliogyro blade
x_j p209m components of state vector
x, y, z p36b Cartesian co-ordinates, left handed per fig. 2.1
p77b Cartesian co-ordinates, right handed per fig. 3.1.3, for

ideal square sail. Corresponding unit vectors are **e**$_1$, **e**$_2$, **e**$_3$.
p165b, Cartesian co-ordinates, with z aligned to sail normal.
z p173m axial cylinder co-ordinate.

° degree symbol
<> p36b time averaged quantity
∂ P36b partial derivative
• p38b dot product cosine included angle
X p36m cross product not correct symbol sine included angle
∫ p42m integral
√ square root
≡ definition
≈ p114b approximately equal
♦ p118b Used as symbol for Aries.
p122m The curved arrowhead is just the regular "less than".
<> p246m averaging symbol
Problems: cross product, **r^** and r dot. Aries symbol. For tilda above use character code 06E4 followed by the character under the tilda.
Need formulae for del notation in various co-ordinate systems.

In cylindrical co-oordinates, del ≡ **ρ^(**∂/∂ρ) + **θ^**(1/ρ)(∂/∂θ) + **z^(**∂/∂z). Note also that **∂ρ/∂θ = θ^ and ∂θ/∂ θ = -r^.** All other partials = 0. And
ρ^X**z^** = **-θ^**, **θ^**X**z^** = **ρ^**, **ρ^**X**θ^** = **z^.**

▿ ariel Unicode ms down triangle♈ ♈

CLCB p69b p76m Continuous Longeron Coilable Boom
DLC p26m,p65m Diamond Like Carbon
IAE p71m Inflatable Antenna Experiment
JPL p71b Jet Propulsion Lab
Lambertian p48m equally bright from any aspect.
LHS notes Left Hand Side
MEMS p97b MicroElectoMechanical Systems
RHS notes Right Hand Side
STEM p69m p70t Storable Tubular Expandable Member
Type I: fixed orbital period (fixed ω) for all radii *r* and projections onto the solar plane ρ. p177
Type II: Period at *r* is same as Keplerian period at *ρ*, so that *ω* = $\tilde{\omega}$.
Type III: Minimum solar sail lightness number *β*. Period derives from this, depending on *z and ρ*.

Ellipse relationships
a = semi-major axis, b = semi-minor axis, f = true anomaly, e = eccentricity
A = aphelion, P = perihelion, r = radius, *v* = speed, *P* = period
γ = flight angle (McInnes version), μ = (M+m)G = gravitational parameter
$a^2 = b^2 + c^2$ $e = c/a$
$r = [a(1-e^2)]/(1 + e(\cos f))$ $r_P = a(1-e)$ $r_A = a(1+e)$ $2a = r_A + r_P$
$(x/a)^2 + (y/b)^2 = 1$ $x = c + r(\cos f)$ $y = r(\sin f)$
$r_1 v_1(\cos f_1) = r_2 v_2(\cos\gamma_2) = r_A v_A = r_P v_P$ $P^2 = (4\pi^2/\mu)a^3$,
$v^2(r) = \mu[2/r - 1/a]$ $v^2(r_P) = 2\mu r_A/[r_P(r_A + r_P]$ $v^2(r_A) = 2\mu r_P/[r_A(r_A + r_P]$
$v^2(r_{circular}) = (\mu/r)$ $v^2(r_{parabolic}) = \mu(2/r)$
$(\cos\gamma)^2 = [1 + e(\cos f)]^2/[1 + e(\cos f) + e^2] = a^2(1 + e^2)/[r(2a - r)]$
Maximum of (cosγ) is $\sqrt{[1 - e^2]}$ and occurs at (cosf) = -e = -c/a, at r = a, or at (x,y) = (0,±b).

Put in index: pitch angle α, cone angle θ p49b p115. see

ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ αβγδεζηθικλμνξοπρςστυφχψω ϑ script theta

α p15mb,p39m,p63m sail pitch angle Fig. 1.12 Angle between sun line and sail normal. Same as resulting force direction if η = 1.
p78t here in x-z plane

p93t angle between sol line (or sail axis?) and net force **n**
p115t Cone angle α is between **n** and **r**.
α p173m,p197b sail pitch angle
$\tilde{\alpha}$ p115m cone angle for arbitrary direction **q**
p137m angle from sun line to **λ**, desired direction of force.
α* p116m, 138t optimum sail cone angle maximizing force in desired direction **q**.
α* p133m optimum sail pitch angle (cone angle?) minimizing logarithmic transfer time.
α* p133m p157b Optimum sail pitch angle.
β p40t,p113b,p118b sail loading parameter. β = (local radiation pressure acceleration)/(local solar gravitation acceleration). AKA lightness number of solar sail.
β p173m sail lightness number. β = 1 (hovers) if σ = σ* = 1.53 g/m^2.

β p215m β = (local radiation pressure force)/(local solar gravitation force), equivalent to above.
β p279m β ≡ v/c = speed as fraction of lightspeed.
Γ p198m scalar potential for solar radiation. Eq.5.67a.
γ p130m angle between sail velocity and circular velocity.
p137b&139m angle between sail velocity and transverse direction.
γ p174t fig.5.1. Not sure of definition. Sail elevation angle p.180b? See eq.5.56 p193m, $\alpha = \gamma$ atan(z/ρ).
γ p279t Lorentz relativistic factor. $\gamma \equiv 1/\sqrt{(1-\beta^2)}$, β ≡ v/c.
Δ p17 change or increment.
∇ del notation.
δ p79b rotation angle of $\mathbf{n_1}$ and $\mathbf{n_2}$, perpendicular to x-axis with δ = 0 hwen they are parallel to **n**. Rotation is clockwise hwen seen from origin.
p115t Clock angle δ is rotation of **n** about **r** measured from reference **p^** perpendicular to orbit plane
$\tilde{\delta}$ p115m Clock angle for arbitrary direction **q**.
δ p137m Clock angle for required force direction **λ**.
δ* p138t optimal clock angle to maximize force in desired direction.
δ p180b perturbation
δ**n**,δγ p189m small changes in **n** and γ.
δα,δκ p207b small changes in sail pitch angle α and acceleration κ.
ε p48bp273m surface emissivity
ε_b p48b,p63m surface emissivity, back of sail
ε_f p48b,p63m surface emissivity, front of sail
ε_0 p36b permittivity of free space
ζ p223b small displacement along z-axis.
η p14t,39b,58t sail efficiency, may be albedo
p164b second parabolic co-ordinate.
p223b small displacement along y-axis.
non-italic theta
θ p43b,p44t angle fig.2.5
θ_0 p43b angular radius of Sol italic θ
p49b cone angle between incoming light and net force, fig. 2.7.
p77b position angle of m_p in fig. 3.13, boom elevation angle
θ p86b blade twist $w \equiv \mathrm{\theta}x$. Not italic. Again, a slope not angle, unless you assume the small angle tangent approximation.
p118t azimuth co-ordinate from Aries ♦ .
p154t reference angle, also f
p164b third parabolic co-ordinate.
θ p174t rotation angle fig.5.1.
p197b rotation angle in fig.5.13, probably WRT x-axis.
p273b diffraction limited divergence angle of laser.
$\mathrm{\theta}_0$ p88m blade twist (aka slope) of heliogyro blade at root. Not italic θ
θ(t) p88b twist (slope) of heliogyro blade at root including collective pitch $\mathrm{\theta}_0$ and cyclic pitch
$\mathrm{\theta}_0$ p88b collective pitch of heliogyro blade

special italic theta ϑ for italic theta, special symbols font.

ϑ   p85m coning angle, actual a slope. $\vartheta = dw/dr$ Italic theta.
ι   iota not used
κ p151m,p162m,198t magnitude of solar sail acceleration, = a_0 at one au.
κ_0 p202m fixed value for sail acceleration for graphing.
Λ_1 p59b Λ_2 Λ_3 sensitivity constants
λ_{IR} p67t Infra-red wavelength
λ   p44t aspect angle. $\lambda = \pi/2 - \theta + \theta_0$, see sec. 2.5.3.
λ_{light} p67t wavelength of visible light
λ   p74t mass of spar per unit length. Note: this should not be a
        constant considering the forces involved change with size.
λ   p273b laser wavelength.
λ*(Z)* p137t $\boldsymbol{\lambda}(Z)=(\lambda_1,\lambda_2,\lambda_3)$ function of sail orbit elements from p120t.
        λ_1 λ_2 λ_3 are the coefficients of ***S,T,W*** from p120t. I think.
μ   p114b,p118b $\mu = G(M+m)$ per unit mass?
μ   p151m $\mu = G(M+m)$ here *M* is mass of Terra.
    $\mu = GM_S = 1.327\ E20\ m^3/s^2$, $\mu = GM_T = 3.986\ E14\ m^3/s^2$.
μm p14t micrometers
μ_0 p36b permeability of free space
$\tilde{\mu}$ p121b effective gravitational parameter, μ~ = μ(1-β).
μ   p214b,p216b $\mu \equiv m_2/(m_1+m_2)$, m_1 the luminous body. For Sol-Terra, μ = 3.036E-6.
ν   p35t photon frequency
ξ p43m $\xi \equiv \cos\theta$
    p164b first parabolic co-ordinate.
    p223b small displacement along x-axis
ξ_E p286t fraction of hydrogen atom kinetic energy transferred to sail.
ξ_P p286m efficiency of momentum transfer from impinging hydrogen atoms.
ο   omicron not used.
π   p40m,p73m pi 3.14159...
ρ   p54   proton number density for high solar wind at 1 au $\doteq$ $4E6/m^3$
ρ   p84b density of heliogyro blade sail film.
    p211 real coefficient of i
ρ P173m radius of orbit displaced distance z from gravitational
        center along orbital axis. ρ is radius from Sol projected
        onto plane containing Sol.
σ   p14t p39m,p56t,p90m,p175m solar sail mass per unit area σ = m/A.
    p221m real component of s.
σ_0 p88m radial stress/unit volume at heliogyro blade root from eq. 3.26a
σ_r p84b radial tensile stress/unit volume in heliogyro blade
σ_S p58t sail assembly loading: mass of sail and structure per unit
        area. $\sigma_S = m_S/A$
σ_x p84b chordwise tensile stress/unit volume in heliogyro blade
σ* p40m critical solar loading parameter. $\sigma^* = L_S/2\pi GM_S c = 1.53\ g/m^2$,
        sail can hover β = 1.
$\tilde{\sigma}$ p48b,p63m,p273m Stephan-Boltzman constant. $5.67E{-8}\ W/m^2K^4$
τ   p47b transmission coefficient, 0 since sail is opaque
τ p120t time of perihelion passage
    p167b time-like variable.
τ_0 p167b constant of motion.
τ p279t proper relativistic time.
τ_0 p280m Time constant. $\tau_0 \equiv m_0c^2/2P$.
υ
Φ   p174b,p198m scalar potential eq.5.3a and eq.5.66a.
    p212t subtends off-solar axis Orbit I in fig.5.21.
φ p43b angle
    p50m centerline angle between force vector and sail normal,
          fig.2.7. $\tan\varphi = f_t/f_n$
    p77b position angle of m_p fig. 3.13, boom azimuth angle from x-axis
    p118t altitude angle
    p203b Fig.5.17 Angle twixt radius from Sol and axis of off-(solar)
           axis Type III orbit.
    p212t Fig.5.21 Angle twixt radius from Sol and axis of off-(solar)
           axis Type III orbit.

χ p182b eq.5.24e.
$\mathbf{\Psi}_\nu(\mathbf{r},\mathbf{u};t)$ p41b photon distribution
$\psi_\nu(\mathbf{r},\mathbf{u};t)$ p41m photon number density. $\psi_\nu = (2/h^3)(e^{h\nu/kT}-1)$ for black body.
ψ_0 p88b phase angle of cyclic pitch of heliogyro blade. Measured in radians?
ψ p157t Angle sun line **l** to sail velocity **v**.
Ω p40b solid angle p43b $d\Omega = \sin\theta d\theta d\varphi$
p119b longitude of ascending WRT Aries. node fig. 4.7.
$\mathbf{\Omega}$ p83b angular velocity of heliogyro radians/s for equations, often rpm in graphs.
p90m angular velocity of disc sail
ω p119b angle between ascending node N and perihelion P fig.4.7.
$\boldsymbol{\omega}$ p174t.p197b angular velocity fig.5.1, fig.5.13.
ω p175b,p199t angular speed $\omega \equiv 2\pi/T$.
$\tilde{\omega}$ p175b Orbital circular velocity for Keplerian orbit with radius r.
p199m Same as above, maybe.
ω_S p223t angular rate synodic lunar month