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Some variable names in the paper - please use these:

**Constants**

c\_speed\_light: Speed of Light

h\_planck: Planck's Constant

g\_n: Gravitational Constant

**Inputs:**

\* m0\_payload\_mass: Payload

\*xi\_sail\_constant : relating size to area: pi/4 for circular, 1 for square sail

\* D\_sail\_size: Sail Size

\* h\_sail\_thickness: Sail Thickness

\* rho\_sail\_density: Sail Density

\* epsilon\_sub\_r\_reflection\_coef: Sail Reflectivity

\* alpha\_reflector\_absorption: Sail absorption

\* xi\_ array\_constant: relating size to area: pi/4 for circular, 1 for square sail

\*alpha\_array\_constant: Related to the first minimum of the Bessel function of the first kind J1. ~1.22 for circular, 1 for rectangular array

\* d\_array\_size: Laser Size

\* P\_optical: Total Optical Power

\* epsilon\_sub\_beam\_beam\_eff: Beam Efficiency

\* lambda\_wavelength: Wavelength of main laser

\* epsilon\_sub\_elec\_photon\_to\_electrical\_eff: Electrical Efficiency

\* energy\_cost: Electrical Energy Cost

\* energy\_storage\_cost: Energy Storage Cost

\* Laser\_comm\_spacecraft\_power\_peak: Peak Laser Comm Power (W)

\* Photons\_per\_bit\_for\_communication: Photons Per Bit for Communication

\* lambda\_laser\_comm\_wavelength: Laser Comm Wavelength (nm)

\*epsilon\_sub\_ Laser\_comm\_beam\_efficiency: Laser Comm Beam Efficiency

\* alpha\_laser\_comm\_optics\_constant:Related to the first minimum of the Bessel function of the first kind J1. ~1.22 for circular, 1 for rectangular array

\* Laser\_comm\_spacecraft\_optics\_size: Spacecraft Laser Comm Optical Size

\* L\_target\_ly: Target Distance in ly

**Outputs:**

\* m\_sail: Sail Mass

\* m\_total\_mass: Total Mass

\* sail\_areal: Areal Density

\* P0\_laser\_power\_in\_main\_beam: Laser Power in Main Beam

\* a\_acceleration: Peak Acceleration

\* L0\_distance\_to\_spot\_size\_equals\_sail\_size: Accel Distance at L0

\* t0\_time\_to\_L0: Time to L0

\* v\_0\_speed\_to\_L0: Speed at L0

\* L0\_ke: Kinetic Energy at L0

\* E\_gamma\_photon\_energy\_in\_main\_beam\_to\_time\_t0: Laser Energy at L0

\* E\_elec\_total\_electrical\_energy\_used\_to\_t0: Electrical Energy at L0

\* energy\_cost\_per\_launch: Electrical Energy Cost at L0

\* energy\_storage\_cost\_per\_launch: Energy Storage Cost at L0

\* v\_infinity\_speed\_with\_continued\_illumination: Limiting Sped

\* Laser\_comm\_flux\_at\_earth: Laser Comm Flux at Earth (ph/s-m^2)

\* laser\_comm\_photometric\_magnitude: Equivalent Photometric Magnitude m\_v

\*Laser\_comm\_rate\_at\_earth: Laser Comm Rate at Earth Received in Array (ph/s)

**Not Used Yet:**

\*P\_electrical\_total\_electrical\_power

\*beta\_0:Beta at Lo = v\_0\_speed / c\_speed\_light

\*beta\_infinity: Beta with continued illumination = v\_infinity\_speed\_with\_continued\_illumination / c\_speed\_light

\*epsilon\_sub\_launch\_eff: efficiency of launch at Lo = L0\_ke/ E\_elec\_total\_electrical\_energy\_used\_to\_t0

\*L\_target\_m= distance to target in meters = 1016\*L\_target\_light\_years

**Notes:**

Laser Comm Flux at Earth (ph/s-m^2)= epsilon\_sub\_laser\_comm\_beam\_eff\*

[Laser Comm Spacecraft Transmit Power (w)/(h\*c/( lambda\_laser\_comm\_wavelength)]/{[L\_target\_m\*2\* lambda\_laser\_comm\_wavelength /Laser Comm Transmit Optics Size (m)/ alpha\_laser\_comm\_optics\_constant]^2}

Laser Comm Rate at Earth Received in Array(ph/s)= Laser Comm Flux at Earth (ph/s-m^2)\*[ xi\_ array\_constant \*(d\_array\_size)^2]

Laser Comm\_effective\_photometric\_magnitude = -2.5\* log (Laser Comm Flux at Earth (ph/s-m^2)/3x1010)

Laser Comm\_received\_wavelength = lambda\_laser\_comm\_wavelength\* [(1+β)/(1-β)]1/2

**General case if sail absorption in addition to reflection added:**

**Then we replace:**

(1+ epsilon\_sub\_r\_reflection\_coef )

**by :**

(2\* epsilon\_sub\_r\_reflection\_coef +(1-epsilon\_sub\_r\_reflection\_coef )\*alpha\_reflector\_absorption)

**IF circular array then can use circular or square sail BUT if square array then use square sail only.**