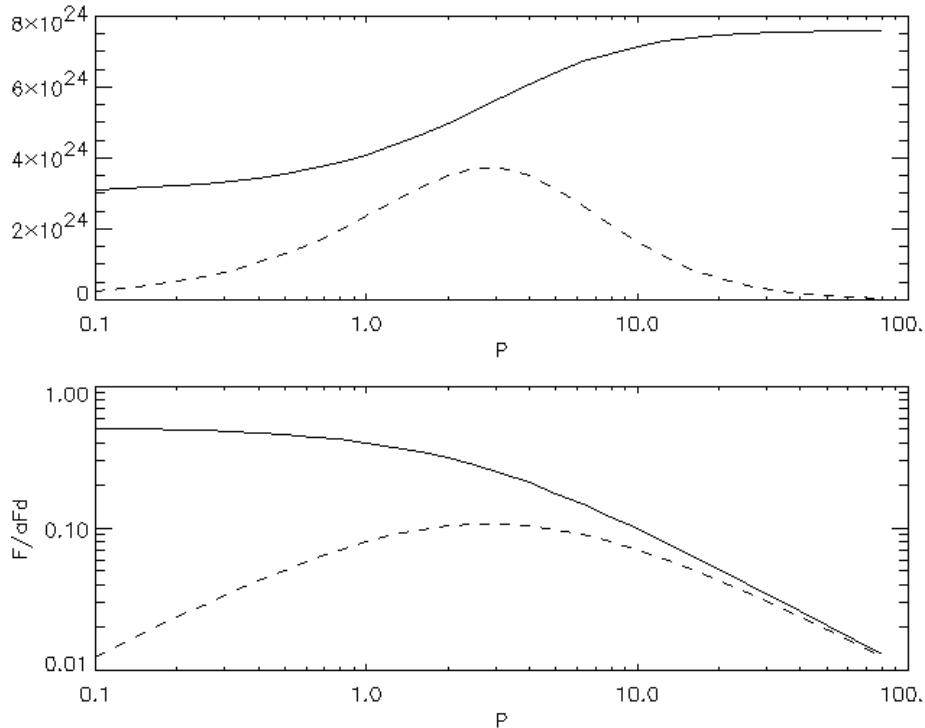


Entropy and the Yarkovsky Effect

R D Lorenz and J N Spitale
Lunar and Planetary Laboratory
University of Arizona

The Yarkovsky effect, the radiation thrust from anisotropic radiation of heat from an illuminated rotating body in space, can significantly modify the orbital energy of that body. It therefore follows that work is being done on the object and even though there is no working fluid, thermodynamic analysis may be instructively applied. The work being done on the object must be reflected in the overall photon entropy budget of incoming sunlight and reradiated heat. The entropy production dS/dt is simply the integral of $I/T - \sigma T^3$ over the object, where T is the local temperature, σ the Stefan-Boltzmann constant and I the absorbed sunlight per unit area. This easy-to-evaluate function increases monotonically with rotation rate – its lowest value occurs for slow rotation, where the peak temperature is obtained; the radiation pressure of the thermal emission is maximized here, although in the antisun direction. For fast rotation and maximum entropy production, the temperature distribution with hour angle is flattest and there is no thermal radiation thrust. The peak Yarkovsky effect, where rotation is slow enough to have a high temperature contrast, but quick enough to swing the temperature bulge away from the noon position, occurs for an intermediate rotation rate. A plot of entropy production against rotation rate has a maximum *slope* ($d(dS/dt)/d\log P$) at this rate. We note that a simple linearized expression for the Yarkovsky effect includes a $(\Delta T/T)$ term – a Carnot efficiency.



(Upper panel) Entropy production rate dS/dt of a rotating cylinder (solid line, arbitrary units) and derivative $d(dS/dt)/d\log P$ (dashed line, even more arbitrary units) with respect to nondimensional rotation period P . (Bottom panel) corresponding thermal radiation pressure forces (solid line, in radial direction; dashed line in orbital direction, the 'Yarkovsky force') normalized to the incident electromagnetic momentum flux. The peak Yarkovsky effect occurs where the entropy derivative is maximum.