Thermal and Gravitational Tides in Hot Jupiters

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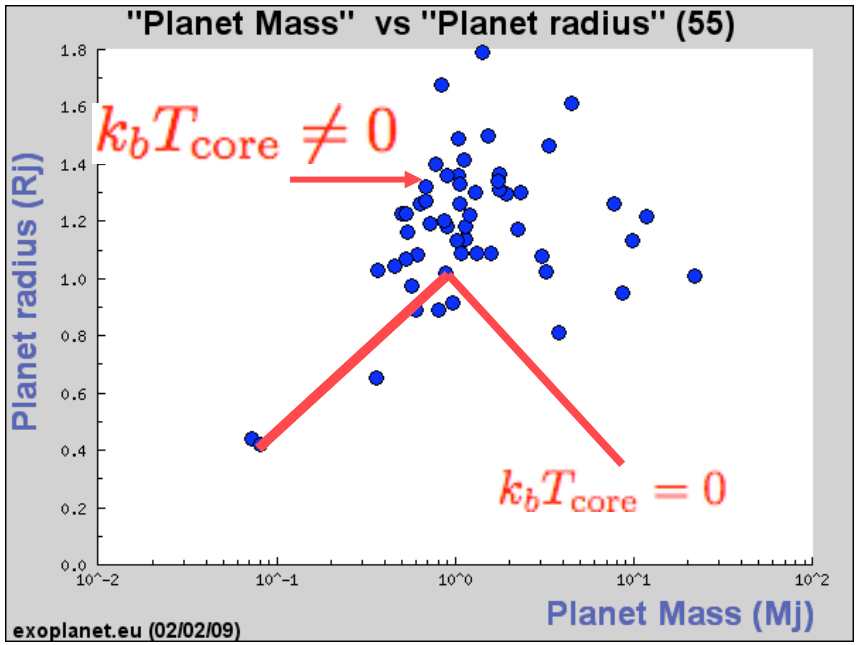
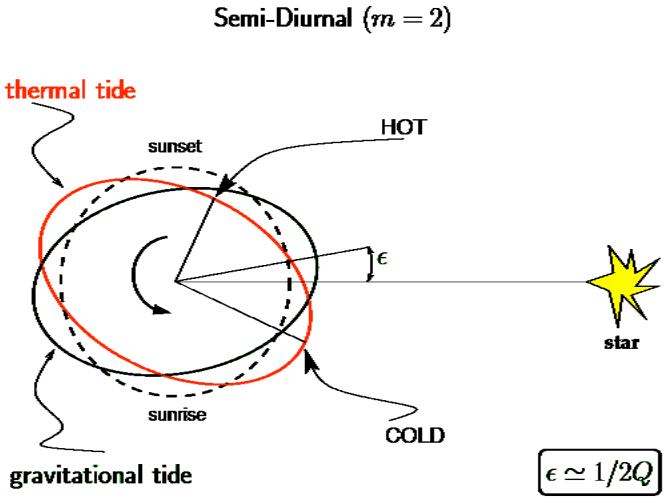
Motivation: radii of transiting planets big => hot.

Need powerful heat source to keep core hot, prevent contraction!



(The Extrasolar Planets Encyclopaedia)

``Thermal tide torque" applied to explain Venus' slow spin (Gold and Soter 1969). Spin rate set by balance of thermal and gravitational tide torques.

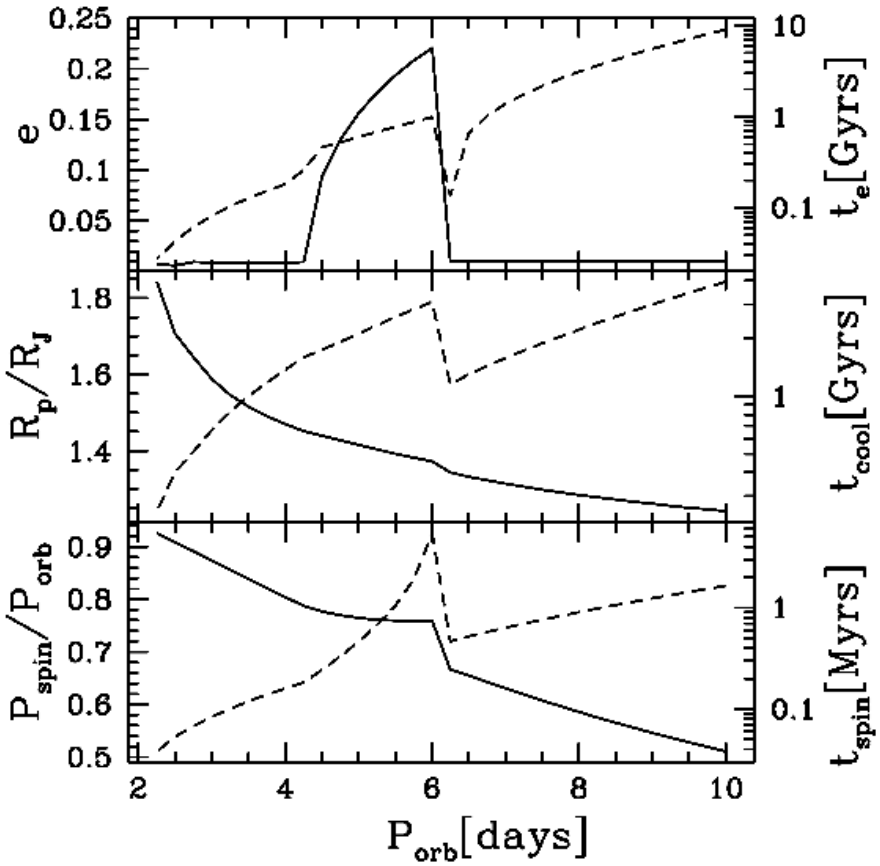


- Time-dependent insolation heats surface causing fluid motion.
- Heating creates a bulge which ***leads*** the thermal/gravitational forcing.

Equilibria:

$$(\text{TT torque}) = (\text{GT torque}) \Longrightarrow \text{spin rate}$$
$$(\text{GT heating}) = (\text{core cooling}) \Longrightarrow \text{radius}$$

Using approximate quadrupole formula due to Gold and Soter, we find highly asynchronous spin and radii bloated due to tidal heating.



Asynchronous torques still exist for thermal forcing of fluid planets, but are complicated by resonant response of internal waves. Work ongoing.