The Origin of Universality in the Inner Edges of Planetary Systems

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Jupiter \((M \approx 0.001 M_{\text{sun}})\)

Trappist 1 \((M \approx 0.09 M_{\text{sun}})\)

Kepler 256 \((M \approx 1 M_{\text{sun}})\)

\(P_{\text{Io}} \approx 1.8 \text{ days}\)

\(P_{\text{b}} \approx 1.5 \text{ days}\)

\(P_{\text{b}} \approx 1.6 \text{ days}\)
Formation of rocky super-earths from a narrow ring of planetesimals

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- silicate-rich composition
- intra-system uniformity
- typical mass ~ few x Earth
- link to Jup, Sol
Orbital migration delivers planets to the disk’s inner edge, where they stabilize. Thus, at face-value, the data appears to suggest that disks are truncated at an orbital period of ~3 days, independent of the central mass…
$P_{\text{mag}} \sim P_{\text{ram}}$

magnetospheric truncation

disk accretion

$B$
We need a theory that will connect stellar field ($B$), radius ($R$), accretion rate ($\dot{M}$-dot) etc.

\[
\frac{B^2}{2\mu_0} \sim \frac{B_*^2}{2\mu_0} \left( \frac{R_*}{r} \right)^6 \sim \frac{\dot{M}}{4\pi r^2} \sqrt{\frac{2G M_*}{r}}
\]
\[
\frac{B_*^2}{2\mu_0} \left( \frac{R_*}{r} \right)^6 \sim \frac{\dot{M}}{4\pi r^2} \sqrt{\frac{2G M_*}{r}}
\]

\[
\dot{M} \sim \beta \frac{M_*}{\tau}
\]

disk accretion rate: \( \dot{M} \)

magnetospheric truncation frequency: \( \Omega \)
\[ \frac{\langle B \rangle^2}{2 \mu_0} \sim \rho v_{\text{conv}}^2 = c f_{\text{ohm}} \langle \rho \rangle^{1/3} (\mathcal{F} q)^{2/3} \]
\[ R_\ast \approx \left( \frac{b G M_\ast^2}{12 \pi q \tau} \right)^{1/3} \]

- bolometric flux
- central body undergoing gravitational (Kelvin-Helmholtz) contraction
- convective dynamo

\[
\frac{\langle B \rangle^2}{2 \mu_0} = c f_{\text{ohm}} \langle \rho \rangle^{1/3} (\mathcal{F} q)^{2/3}
\]
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\begin{align*}
\Omega &= 2 \xi \left[ \frac{\sqrt{2}}{(3 b F)^2} \left( \frac{\pi \beta \gamma^2}{c f_{\text{ohm}}} \right)^3 \frac{(G \langle \rho \rangle)^3}{\tau} \right]^{1/7} \\
&\approx 2.4 \times 10^{-5} \text{ s}^{-1} \approx \frac{2 \pi}{3 \text{ day}}
\end{align*}