M-dwarf planets form rapidly and forget their initial conditions

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Why should we care?
- TESS is expected to find hundreds of M-dwarf planets
- Efforts to reverse-engineer initial conditions from modern observations may not be meaningful
- We should be cautious when using TESS data in the context of planet formation research

Methods
- We run N-body simulations around a 0.2 $M_\odot$ star using the MERCURY code with the hybrid integrator
- 147 embryos per run with initial masses of 0.08 $M_\oplus$
- Solid surface density follows a uniform power law:
  \[ \Sigma = \Sigma_0 r^{-\gamma} \]

\begin{tabular}{|c|c|c|c|}
\hline
Model & $\gamma$ & Gas disk? & $a_{\text{init}}$/AU \\
\hline
Mix.1 & 0.6 & No & 0.033 – 0.26 \\
Mix.2 & 0.6 & Yes & 0.033 – 0.26 \\
Mix.3 & 0.6 & Yes & 0.033 – 0.52 \\
\hline
Frag.1 & 1.5 & No & 0.033 – 0.26 \\
Frag.2 & 1.5 & Yes & 0.033 – 0.26 \\
Frag.3 & 1.5 & Yes & 0.033 – 0.52 \\
\hline
\end{tabular}

- **Mix Models**: Dust particles are well-mixed with the gas; solids mirror the viscously heated inner disk
- **Frag Models**: Dust sizes are fragmentation-limited; aerodynamic drag rearranges the solids

Results
- Collisions peak at $\sim 10^3$–$10^6$ years
- Nearly all collisions occur within the simulation’s first 1 Myr
- Planets mostly form before the gas disk dissipates

- Models with a gas disk make planets that migrate inward
- All models that include gas produce planets with similar orbital characteristics

- For all models, final density profiles are completely different from the initial embryo distribution
- The presence of a gas disk does not affect this result

Conclusions
- Planets form quickly, long before the gas dissipates
- Planet formation reshapes the solid distribution and destroys memory of the initial conditions
- However, planets remember whether gas was present during formation

Results (cont.)

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