Hierarchical accretion, melting by short circuits, and the origins of chondritic planetesimals

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Refractory CAIs and chondrules contain many elements in abundances complementary to those in the low-temperature matrix component, yielding solar proportions in chondritic meteorites [1-5]. Kuiper belt Comet Wild2 contains refractory inclusions similar to but much smaller than inclusions in chondrites [6]. Hierarchical growth from d<1μm to d=1mm components [7] requires repeated highly local heat pulses (>1300 K) that preserve nearby presolar grains and macromolecular C, so all can accrete together into chondrites or cometary material, precursors to planets.

Nebular dust heating models are criticized for lack of a heating mechanism [8]. However, recent magnetohydrodynamical models have demonstrated that dissipation of gravitational potential energy can drive the needed heating [9] through gravitational (GI) or magnetorotational instabilities (MRI). MRI creates current sheets, which can steepen from runaway thermal ionization [10,11], producing highly localized heating in dust-rich nebular regions.

Current sheets could locally heat inclusion precursors that cool through Curie temperatures distal to high fields, recording low field strength paleomagnetism [12], without heating nearby matrix. The current sheet mechanism is consistent with complementarity and much of the observed phenomenology of chondrites and cometary materials. The spatial extent of MRI-based heating is not fully understood.

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