Constraining K depletion in magnetorotationally unstable protoplanetary disks

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Accretion of matter onto the central star in a protoplanetary disk requires outward angular momentum transport. Conversion of orbital kinetic energy to magnetic energy through the magnetorotational instability (MRI) is one hypothesized mechanism for this process, and is thought to operate in disk regions with sufficiently high electron densities to exceed the threshold magnetic Reynolds number. Current sheets engendered by the MRI may supply the requisite heating mechanism for chondrule melting through a short-circuit instability capable of highly localized intermittent flash heating to above 1300 K [1, 2].

In regions of the disk hotter than ~1000 K, the dominant source of free electrons is potassium, the most easily ionized alkali metal sufficiently abundant in the solar nebula. Therefore, mineralogy and dynamics are coupled; theoretical and observational constraints on the condensation behavior of K are critical to understanding the evolution of the disk. The canonical 50% *equilibrium* condensation temperature of K in a vapor of solar composition [3] is misleadingly high at $T_{50\%}$ = 1006 K, and predicts mineral assemblages not observed in most meteorites. Al and Si are demonstrably sequestered in CAIs and chondrule mesostasis at higher temperatures, and therefore unavailable to condense with K as feldspar. K depletions of up to 60% in CV, CO and CM chondrite classes [4] and even higher in Mars, Mercury and the primitive upper mantle of the Earth [5] suggest that K persisted in the gas phase in the inner solar system – a result consistent with the MRI current sheet heating hypothesis. The absence of K in condensed phases must be considered in constructing a self-consistent picture of the early stages of planet formation in the disk. We are exploring the effects of disequilibrium gas phase K abundances on the short-circuit instability.

[1] Hubbard *et al* (2012) *ApJ* **761**, 58 [2] McNally *et al.* (2013) *ApJ* **767,** L2-7 [3] Lodders (2003) *ApJ* **591**, 1220-1247 [4] Wasson & Kallemeyn (1988) *Phil. Trans. Roy. Soc. London* **A325,** 535-544 [5] Peplowski *et al* (2011) *Science* **333**, 1850-1852