PLANETESIMAL FORMATION: EVIDENCE FOR A UNIVERSAL INITIAL SIZE DISTRIBUTION.
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Introduction: Planetesimals are the precursors to planets, and understanding their formation is an essential step towards developing a complete theory of planet formation, whether it be that of our own solar system or of the many extrasolar planetary systems discovered in recent years. Furthermore, a detailed understanding of planetesimal formation is necessary for explaining the observed properties of asteroids and Kuiper Belt objects.

Traditional theories attempt to explain planetesimal formation from a "bottom-up" approach; small particles (e.g., dust grains) continually grow upward in mass and scale, finally reaching gravitationally bound objects. For these small solid particles to coagulate into planetesimals, however, requires that these particles grow beyond centimeter sizes; with traditional coagulation physics, this is very difficult [1,2]. The streaming instability [3,5], however, generates sufficiently dense clumps of these smaller constituents that the mutual gravity between the particles eventually causes their collapse towards planetesimal mass and size scales.

Results: Here, we present a series of high resolution, first principles numerical simulations of protoplanetary disk gas and dust to examine in detail, the formation of planetesimals and their resulting size frequency distribution. We find that their differential size distribution can be well-modeled as a power law with power law index -2.8. This equates to a top-heavy distribution, with most of the mass in the largest objects (see Figure 1). This power law index is robust to resolution, initial particle size and concentration, relative strength of gravity to tidal shear, and conditions prior to collapse. We present tentative evidence that this universality can be tied to the power spectrum of particle mass density prior to collapse.

References: [1] T. Birnstiel et al. (2010) *A&A,* 513, A79. [2] J. Blum & G. Wurm (2008), *ARA&A*, 46, 21. [3] A. Johansen et al. (2007), *Natur*, 448, 1022. J. B. Simon et al. (2016), *ApJ*, 822, 55 [5] A. N. Youdin, & J. Goodman, (2005), *ApJ*, 620, 459.

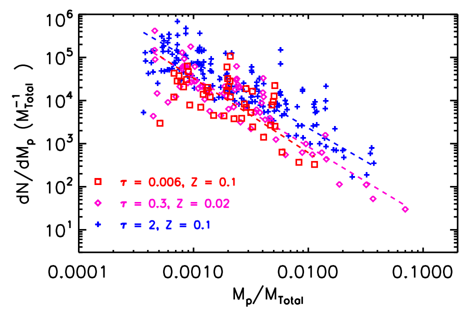

Figure 1 - The initial differential planetesimal mass function derived from simulations with different particle Stokes numbers, τ, and concentrations, Z. The simulation with the smallest particles (τ = 0.006, red) forms a significantly smaller total mass of planetesimals during the duration of the run, but no significant differences in the slope of the derived mass function are observed. The best fit power law is overplotted as dashed lines. (This figure is a modified version of Fig. 2 in [4]).