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An inflationary disk phase of protoplanetary disks

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Understanding planetesimal formation is an essential first step to understanding planet formation. The distribution of these first solid bodies will drive the locations where planetary embryos can grow, eventually leading to fully-fledged planets [1, 2].

For the Solar System, a given disk formation and evolution model needs to meet at least the following three criteria:

1. It must produce an extended gas and dust disk (e.g., ~45 au for the dust [3]).
2. Within the disk, the local dust-to-gas ratio in at least two distinct locations must sufficiently increase to explain the early formation of the parent bodies of non-carbonaceous (NC) and carbonaceous (CC) iron meteorite [e.g., 4].
3. Dust particles, which have condensed at high temperatures (i.e., CAIs), must be transported to the outer disk [5].

Recent 1D disk models tracking the evolution of disk and planetesimal formation can satisfy criteria 2 & 3 but not 1 [e.g., 6-9]. Their disks extend only slightly beyond the water snowline (~5 au) because of the rapid dust growth beyond the snowline and subsequent drift back towards the proto-star due to aerodynamic drag in the tangential direction [e.g., 10, 11]. Models where material falls into the disk at large distances [e.g., 12] naturally satisfy criteria 1 and, in some cases, 2 but not 3.

We will show that an initial rapid expansion -- forming an inflationary disk stage -- can satisfy all three conditions. Such a disk stage can be induced, e.g., by a high initial viscosity of the gas disk.

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