The Jeans Mass as a Fundamental Measure of Self-Gravitating Disc Fragmentation and Initial Fragment Mass

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As a formation route for objects such as giant planets and low-mass stars in protostellar discs (as well as stars in AGN discs), theories of self-gravitating disc fragmentation need to be able to predict the initial masses of fragments. We describe a means by which the local Jeans mass inside the spiral structure of a self-gravitating disc can be estimated. If such a self-gravitating disc satisfies the criteria for disc fragmentation, this estimate provides a lower limit for the initial mass of any fragments formed. We apply this approach to a series of self-gravitating protostellar disc models, to map out the typical masses of fragments produced by this formation mode. We find a minimum fragment mass of around 3 Jupiter masses, which is insensitive to the stellar mass, and that - within the parameter space surveyed - fragments with masses between 10 and 20 Jupiter masses are the most common. We also describe how the Jeans mass allows us to derive a more general criterion for disc fragmentation, which accounts for the processes of viscous heating, radiative cooling, accretion and the disc's thermal history. We demonstrate how such a criterion can be determined, and show that in limiting cases it recovers several fragmentation criteria that have been posited in the past, including the minimum cooling time/maximum stress criterion.

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