Protostellar Collapse Induced by Compression.

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abstract We investigate numerically and semi-analytically the collapse of low-mass, rotating prestellar cores. Initially, the cores are in approximate equilibrium with low rotation (the initial ratio of thermal to gravitational energy is $\alpha_0 \simeq 0.5$, and the initial ratio of rotational to gravitational energy is $\beta_0 = 0.02$ to $0.05$). They are then subjected to a steady increase in external pressure. Fragmentation is promoted – in the sense that more protostars are formed – both by more rapid compression, and by higher rotation (larger $\beta_0$).

In general, the large-scale collapse is non-homologous, and follows the pattern described in Paper I for non-rotating clouds, viz. a compression wave is driven into the cloud, thereby increasing the density and the inflow velocity. The effects of rotation become important at the centre, where the material with low angular momentum forms a central primary protostar (CPP), whilst the material with higher angular momentum forms an accretion disc around the CPP. More rapid compression drives a stronger compression wave and delivers material more rapidly into the outer parts of the disc. Consequently, (i) there is more mass in the outer parts of the disc; (ii) the outer parts of the disc are denser (because the density of the material running into the accretion shock at the edge of the disc is higher); and (iii) there is less time for the gravitational torques associated with symmetry breaking to redistribute angular momentum and thereby facilitate accretion onto the CPP. The combination of a massive, dense outer disc and a relatively low-mass CPP renders the disc unstable against fragmentation, and leads to the formation of one or more secondary protostars. At their inception, these secondary protostars are typically four or five times less massive than the CPP.

For very rapid compression there is no CPP and the disc becomes more like a ring, which then fragments into two or three protostars of comparable mass.

For more rapid rotation (larger $\beta_0$), the outer disc is even more massive in comparison to the CPP, even more extended, and therefore even more prone to fragment.