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Prestellar Core Collisions - Impact on the formation of the CMF? A case study on FeSt 1-457

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Abstract. The initial mass function (IMF) is a profoundly studied subject, however its origin is still unclear and heavily disputed. The Core Mass Function (CMF) has a remarkable resemblance to a shifted IMF along the mass axis of a factor of 3. This CMF has been observed amongst others in the Pipe Nebula, a calm molecular cloud at approximately 130 pc. We study the origin of the CMF under the assumption that collisions and merging of prestellar cores shape the CMF. We present our preliminary results of core collisions for the well known FeSt 1-457.

Keywords. ISM: clouds, kinematics and dynamics

1. Introduction

In the timeline of star formation, a molecular cloud has to lose $6 - 7$ orders of magnitude of its initial specific angular momentum. This loss happens in distinct stages due to various processes (e.g. magnetic braking, fragmentation and turbulence). The first entities formed out of fragmenting filaments are structures of several Jeans masses. Often these objects have small separations and could collide in regions of high core density. Indeed colliding clouds, filaments and prestellar cores have been already identified (Frau *et al.* 2015; Alves & Burkert 2009). To study the effects of these collisions on the loss of angular momentum, we use in this specific example truncated Plummer spheres in a variety of initial conditions. The resulting v_{lsr} gradient of the 2D projected core, the oscillation patterns and dissipated material after the merge will help in the identification and interpretation of real observed cores.

2. Motivation

Several prestellar Cores in the Pipe Nebula show a quasi stable state. The observed cloud cores from Rathborne *et al.* (2009) and Roman-Zuniga *et al.* (2010) are distributed like a shifted IMF. Further studies have shown that the v_{lsr} of the cores can be split into two groups with 2-4 km/s and 6-7 km/s indicating filamentary structures oriented E-W and N-S (Frau *et al.* 2015). The authors propose a filamentary collision and therefore objects especially in the so called bowl of the Pipe Nebula are of great interest for possible colliding candidates.

3. Methods and preliminary results

We use the Herschel column density maps and data from the literature for core selection. The criteria for the selected cores are an elongated shape or a close core within the distance of a Jeans length. First we analyze each single core and subsequently test collision scenarios with the smoothed particle hydrodynamics code called GANDALF (Hubber *et al.* 2018). The simulations were run with and without moderate turbulence and a Boss Bodenheimer test was performed. The cores 94 and 96 fall into the higher velocity filament with 6.3 and 5.87 km/s respectively and are located at the rim of the bowl. By extrapolating the velocity gradient of FeSt 1-457 along the northeast-southwest direction of 1.8 km/s (Aguti *et al.* 2007) to the local surrounding structure we find that the cores collide within 10^5 yrs starting with their current separation of 0.1 pc. This collision produces a clear shock wave between the two cores, which was not observed by any author.

The small velocity dispersion of the line broadening and the small difference in v_{lsr} would speak for a fragmentary origin. A Boss-Bodenheimer test with the current rotation of 10^{-14} radians implemented from the observed small velocity gradient of core 96 could not fit the current observations. The literature is divided whether the core is stable or unstable, but Aguti *et al.* (2007) and Juarez *et al.* (2016) agree that it is at the rim of stability. However, we calculate that FeSt 1-457 exceeds the critical Bonnor Ebert mass and should collapse and therefore star formation will set in before the two cores (94 and 96) can merge by pure gravitational interaction. A simulation of two equally sized prestellar cores colliding with velocity of 1.8 km/s did not instantly collapse after the collision but a slower motion of drifting apart with slight preference to dispersal was observed. We notice here that no background gas is implemented as external pressure in the simulations, although it could have a considerable effect on the pulsation of the cores (Aguti *et al.* 2007). The initial setup for this simulation were two 2 $M_\odot$ cores with plummer density profile at a separation of 0.1 pc. Our study has shown that two prestellar cores with plummer density profile could produce a 4 $M_\odot$ core with an elongated bullet-shaped companion. This structure is however not stable and collapses without any further support.

4. Conclusion and future implications

We use the two-fluid version of GANDALF adding a dust component to study the observable dynamics. Especially in the case of the bullet companion the shown diverging behaviour of larger dust grains from gas dynamics is of great interest.

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