3D SPH simulation of supersonic collision between GMC and ISM
A mode for Super Star Cluster formation

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Abstract

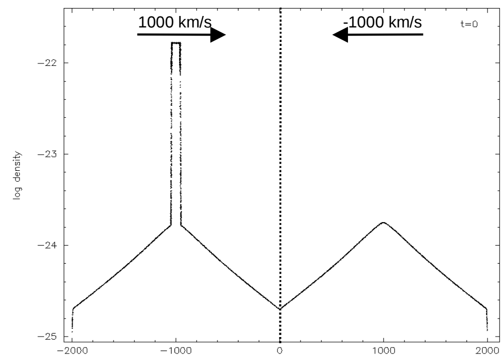
We present a 3D SPH simulation of a supersonic collision between two disk galaxies, one of which has a Giant Molecular Cloud (GMC) embedded in its Interstellar Medium (ISM). The collision results in a hot ($T \sim 10^8$ K) shock layer. When the GMC passes through this layer, it is compressed, leading to the formation of dense ($\rho \sim 10^{-18}$ g/cm^3), cold ($T<100$ K), and Jeans-unstable sub-regions. We propose that Super Star Clusters (SSCs) may form via this mechanism.

Introduction

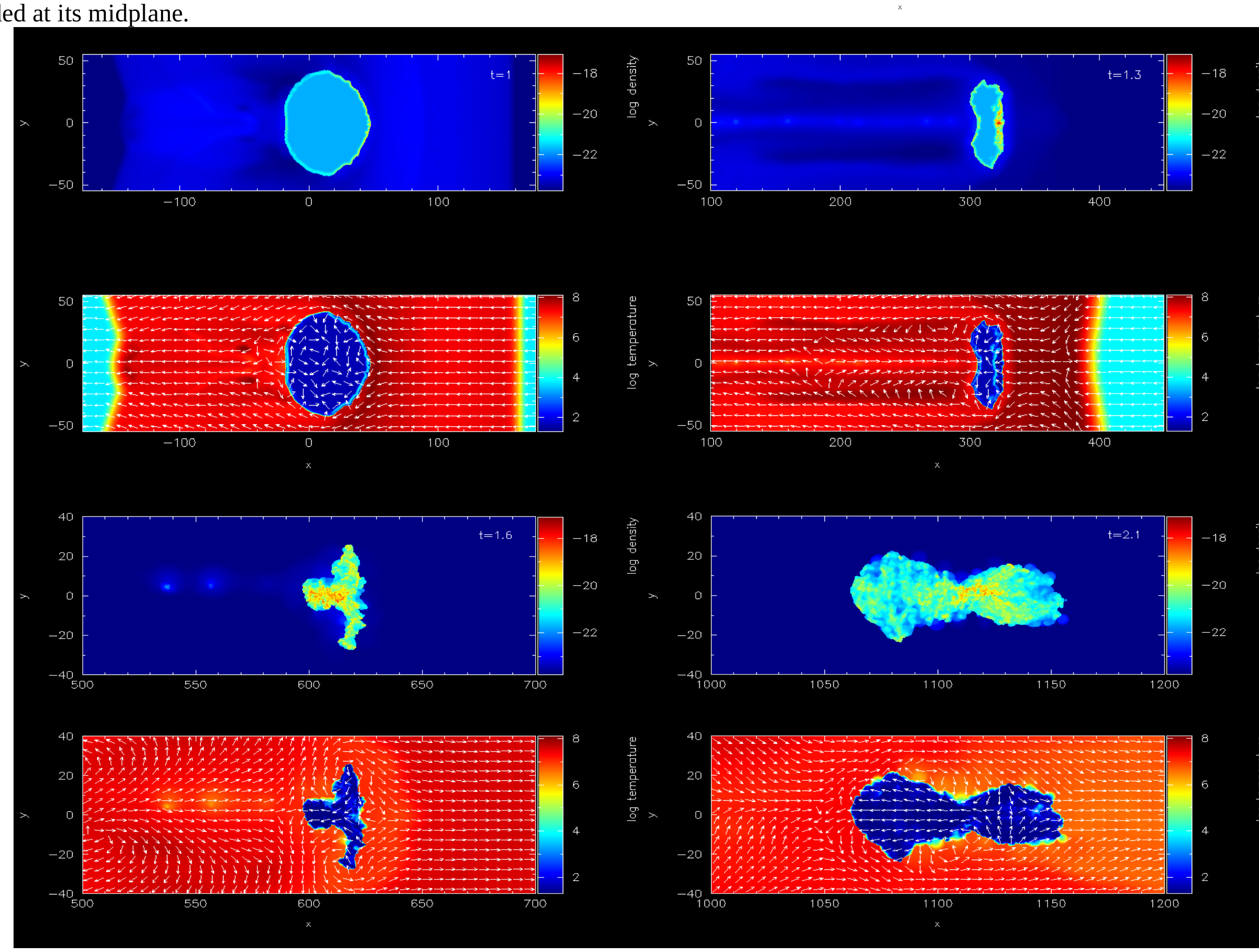
SSCs are the most massive known star forming regions. They are dense regions containing a few thousands up to millions of stars packed in an area of only a few parsecs across. One of the most important and thus far unanswered questions is how to gather the gas in a small volume to form these objects. We consider a head-on collision between two galaxies, as shown in the diagram on the right. We perform a 3D SPH simulation of two columns of gas representing parts of the colliding disks, one of which has a GMC embedded at its midplane.

Numerical Treatment

We use the MPI-parallelized SPH code SEREN (Hubber et al. 2010 *submitted*, http://www.astro.group.shef.ac.uk/seren). We use an equation of state including cooling and heating based on the Plewa (1995) and Koyama & Inutsuka (2000) cooling functions.



The plot on the left shows the density (g/cm^3) profile of the initial conditions. The x axis is in pc. The galaxies collide with an effective 2000 km/s velocity.



Results

The above figure shows density (g/cm^3) and temperature (K) cross section plots (z=0pc plane) at different times (t=1, 1.3, 1.6, 2.1 Myr). The vector plot on top of the temperature map shows the direction of the velocity field, after subtracting 1000km/s of velocity. The axes are in pc. At ***t*=1Myr** a well-defined shocked layer has formed with temperature of order $T \sim 10^8$K. Here, the GMC is deep inside this layer and it has been wrapped up by the hot medium whose thermal pressure compresses it from all sides. In addition, the ram pressure resulting from the cloud's supersonic motion through the hot medium compresses it further along the collision axis. At ***t*=1.3Myr** a dense ($\rho \sim 10^{-18}$ g/cm^3) core is formed, which later at ***t*=1.6Myr** deforms into a filamentary structure and which partially re-expands due to internal thermal pressure. For ***t*>2.1Myr** the GMC exhibits a peanut shape, whose central region contains Jeans-unstable sub-regions. In the future, we will explore the possibility that such a structure collapses and forms an SSC.

References

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The column density plots were made using SPLASH (Price D.J., 2007, PASA, 24, 159)