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Formation of Globular Clusters in Galaxy Mergers

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Abstract. Our numerical simulations first demonstrate that the pressure of ISM in a major merger becomes so high ($> 10^5$ k_B K cm^{-3}) that GMCs in the merger can collapse to form globular clusters (GCs) within a few Myr. The star formation efficiency within a GMC in galaxy mergers can rise up from a few percent to $\sim$ 80 percent, depending on the shapes and the temperature of the GMC. This implosive GC formation due to external high pressure of warm/hot ISM can be more efficient in the tidal tails or the central regions of mergers. The developed clusters have King-like profiles with an effective radius of a few pc. The structural, kinematical, and chemical properties of these GC systems can depend on the orbital and chemical properties of major mergers.

1. Implosive formation of globular clusters

Several authors have suggested that very high pressure of ISM expected in major galaxy merging can be responsible for the rapid (triggered) collapse of GMCs and the subsequent GC formation (e.g., Elmegreen & Efremov 1997; Bekki et al. 2002). We numerically investigate the key questions on this GC formation scenario: whether or not the star formation efficiency within a GMC under such high pressure ISM can be as high as that (> 50 %, e.g., Hills 1980) required for the bound cluster formation. Figure 1 shows that the high pressure of the ISM can continue to strongly compress the cloud without losing a significant amount of gas from the cloud. As the strong compression proceeds, the internal density/pressure of the cloud can rise so significantly that a GC can form from the gas of a starburst (See the caption of Fig.1 for the detail of this).

References

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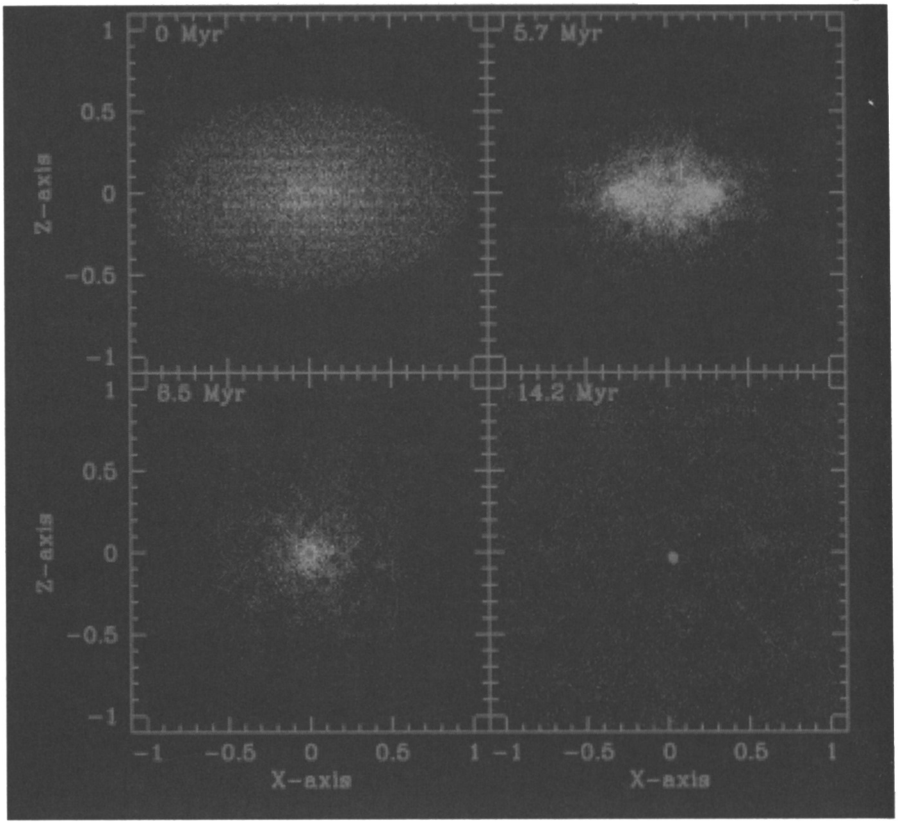

Figure 1. Time evolution of a GMC embedded by high pressure ISM for gaseous components (cyan) and for new stars formed from the gas (magenta). For clarity, the surrounding high pressure warm/hot ISM with $P \sim 10^5$ k_B K cm^{-3} is not shown. The mass and the size of the initial GMC is $10^6 M_{\odot}$ and 97 pc, respectively. The oblate shape of the cloud is assumed in this model (the long-to-short-axis-ratio is set to be 0.6). The initial sound velocity of the gas in GMC is $\sim$ 5 km s^{-1}, for which the GMC can not collapse owing to its self-gravity (if the surrounding ISM's density and pressure are as low as those observed in disk galaxies). One frame measures 200 pc on a side. Note that a very compact GC is formed owing to strong external compression of the GMC by the hot, high pressure ISM. About 80 % of the initial gas is converted into new stars within a few Myr so that the developed compact stellar system with the effective radius of a few pc can be strongly bounded even after the removal of the remaining gas. Due to the rapid, dissipative collapse, the gaseous density of the cloud dramatically rises and consequently star formation begins in the central regions of the cloud. The star formation rate increase significantly to 1.5 $M_{\odot}$ yr^{-1} (8 Myr after the start of the cloud's collapse). Because of the "implosive" formation of stars from strongly compressed gas, the developed stellar system is strongly self-gravitating and compact. This result implies that high external pressure from the ISM is likely to trigger the formation of bound, compact star clusters rather than unbound, diffuse field stars (astro-ph/0308263 for color version).