N-body/SPH study of the evolution of dwarf galaxies in a cluster environment

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Using an N-body/SPH code, we explore the scenario in which a dwarf elliptical galaxy (dE) is subjected to ram-pressure stripping due to the intracluster medium (ICM). We suppose that the dwarf galaxy contains an ionized interstellar medium (ISM) with a temperature of10^4 K, in hydrostatic equilibrium with the Burkert dark matter potential. We varied the mass of the dark matter halo from 10^6 to 10^{10} $M_\odot$, while the relative velocity of the galaxy through the cluster was fixed at 1000 km s^{-1}. Initially, the ionized ISM is set up to be pressure confined within the surrounding ICM. This is in contrast to the simulations of Mori & Burkert (2000), where the ISM is density confined. Also, in Mori & Burkert, the ISM temperature varies with dark matter mass ($T_{\rm ISM} \propto M_{\rm dm}^{4/7}$), ranging from 6×10^2 K to 1.3×10^5 K. Since the ISM is supposed to be ionized by supernova heating, a constant temperature of 10^4 K is presumably more physically motivated.

In a typical cluster environment ($\rho_{\rm ICM} = 10^{-4}\,{\rm cm}^{-3}$, $T_{\rm ICM} = 10^7$ K) we find that smaller dwarf galaxies ($M_{\rm dm} < 10^8\,M_\odot$) are instantaneously stripped of their ISM, confirming the results of Mori & Burkert. However, the central pressure in the more massive dwarfs ($M_{\rm dm} \geq 10^9\,M_\odot$) is considerably higher than in the Mori & Burkert simulations, due to the lower temperatures. Therefore, these dEs are able to retain their ISM over several dynamical time-scales (up to a few Gyrs), during which the gas may cool and form stars. Star formation is furthermore enhanced by the increased density due to the ram-pressure of the ICM. In a next step, radiative cooling, star-formation and stellar feedback will be included to realistically capture the effects of the compression of the interstellar medium. Thus, our simulations show that while (i) smaller dEs lose their ISM almost immediately after entering the cluster, (ii) more massive dEs are able to retain their gas for considerable timespans.

Although dEs were mostly believed to be gas-poor systems, having lost their gas either through a galactic wind or by ram-pressure stripping in a dense group/cluster environment, recent observations show that some dEs in cluster environments are indeed able to retain some of their gas and even show evidence for recent or ongoing star formation. (See e.g. De Rijcke et al., 2003 and Michielsen et al., 2004 for detailed observations of Hα in Fornax dEs.)

References:

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