The early impact of ionizing radiation on early forming clouds

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Molecular clouds condense out of the diffuse interstellar medium. Their internal substructure, which is most likely already imprinted during the process of cloud formation, act as sites for star formation. The dense gas in the clouds is affected by stellar feedback soon after star formation. Feedback acts a counter to gas accretion, limiting the mass of stars; it may also trigger the formation of new stars in nearby dense clumps. We perform radiative hydrodynamic simulations with the adaptive mesh refinement code Flash 4 which apply the novel, tree-based, radiative transfer scheme TreeRay (Wünsch et al. 2017, MNRAS accepted). Photo-ionizing radiation is self-consistently coupled to a chemical network to follow gas heating, cooling and molecule formation and dissociation. As part of the SILCC-ZOOM project (Seifried et al. 2018, MNRAS 472) we present the results for two molecular clouds forming from a turbulent multi-phase ISM down to sub-parsec resolution. The clouds have similar initial masses, similar escape velocities, and a similar initial energy budget. We follow the formation of star clusters with a sink based model and ionizing radiation from individual massive stars (Haid et al. 2018, MNRAS submitted). For the first 3 Myr of cloud evolution we find that the overall star formation efficiency is reduced by a factor of 4, reaching values below 10 percent, in agreement with observations. The mass accretion on sinks is terminated after their initial 0.5 Myr of evolution. Despite the global low efficiency, star formation is triggered close to the first population of stars. The second generation is sufficiently massive to produce feedback and so, in concert with the first population, the cloud is dispersed by radiation. The time scale on which the clouds are dispersed is sensitive to the cloud substructure, particularly on the amount of gas at high visual extinction. Highly shielded regions of the cloud are unaffected by radiation. We also show that the radiation input from the massive stars is deposited as thermal and kinetic energy into the clouds. This keeps these energies at roughly constant levels over the clouds' late evolution, supporting the clouds against gravitational collapse. These results underline the importance of ionizing radiation from massive stars, regulating the energy budget of the clouds, regulating the star formation efficiency, and triggering new star formation.

Molecular Clouds