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Observations and Chemical Modelling of Edge Cloud 2

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Abstract.

Edge Cloud 2 (EC2) is a large molecular cloud with one of the largest galactocentric distances known in the Milky Way ($R_{\rm gc} \sim 24\,$kpc). We use observations of EC2 to determine its physical characteristics. A temperature of 20 K was estimated from our ammonia detections and a gas density of $n(\mathrm{H_2}) \sim 10^4\,\mathrm{cm^{-3}}$ was determined by comparing LVG models of a number of species to their deconvolved line detections. Taking the clumpy structure of EC2 into account, we also calculated $M_{\rm EC2} \sim 10^4\,M_{\odot}$, and from peak continuum emission we calculated a dust mass for EC2 and a dust-to-gas mass ratio ≥ 0.001. To establish the most likely chemical and physical properties of EC2, we made a pseudo-time-dependent chemical kinetic model. This uses our observationally derived temperatures and densities and varies elemental initial abundances, photon flux, cosmic ray ionisation rate and gas-to-dust ratio in an attempt to fit the observed results. We found that heavy elements may be depleted by a factor of $\sim$5 relative to local molecular clouds. The models also suggest a high UV photon field in EC2 ($10 - 20\times$ local values). Some of our models indicate that steady-state is reached very quickly after around 5,000 yr. Our observed high abundances of the radicals $\mathrm{C_2H}$ and CN are typical of photon-dominated regions. This may be related to a large value of the UV flux to grain surface area compared to local clouds. Our best-fit models are consistent with reduced elemental abundances and a low dust-to-gas mass ratio. Such reduced abundances may be attributed to the low level of star formation in this region, and are probably also related to the continuing infall of low metallicity halo gas since the Milky Way formed. Although EC2 does contain young stars, there is no evidence of the late-type stars which produce dust grains, thereby justifying the assumption of a high ratio of UV flux to grain surface area. We conclude that despite the position of EC2 in the Galaxy, UV photons (rather than cosmic rays) play an important role in establishing its detailed chemical composition. Given that EC2 is in a region of extremely low gas pressure and very small spiral arm perturbation, questions remain as to the origin of its morphology and dynamics. A SNR associated with EC2, GSH 138–01–94, is the largest and oldest SNR known in the Milky Way. It consists of a HI shell with an expansion velocity of $\sim$12 km s^{-1} and an expansion age of 4.3 Myr, so EC2 could be as young as the ages derived from our time-dependent calculations. We conclude that the formation, structure and subsequent chemistry of EC2 may be the direct result of shock fronts from GSH 138–01–94 propagating through the medium between 10^3 and 10^4 yr ago.