Synchrotron emission in molecular clouds, from the diffuse medium to dense cores and protostellar jets: the SKA view

Abstract

Understanding the role of magnetic fields in star-forming regions is of fundamental importance. The interpretation of Galactic synchrotron observations is complicated by the degeneracy between the strength of the magnetic field perpendicular to the line of sight and the cosmic-ray electron (CRe) spectrum. In the near future, the exceptional sensitivity of the Square Kilometre Array (SKA) will offer a unique opportunity to evaluate the magnetic field strength in molecular clouds and cloud cores through synchrotron emission observations. The most recent Voyager data, together with Galactic synchrotron emission and Alpha Magnetic Spectrometer data, constrain the flux of interstellar CRe down to 3 MeV, in particular in the energy range relevant for synchrotron emission in molecular clouds at SKA frequencies. We illustrate analytically and numerically the impact that different realisations of the CRe spectrum have on the interpretation of the spatial variation of the spectral index. We then explore the capability of SKA in detecting synchrotron emission in two starless molecular cloud cores in the southern hemisphere, B68 and FeSt 1-457, showing that it will be possible to reach signal-to-noise ratios of the order of 2 to 7 at the lowest frequencies observable by SKA with one hour of integration. We finally show predictions for non-thermal emission at the smaller scales of low- and high-mass protostellar jet shocks, where the local acceleration of electrons is expected.