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# Protostars as cosmic-ray factories

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## Abstract

It is largely accepted that Galactic cosmic rays, pervading the interstellar medium, originate by means of shock waves in supernova remnants. Cosmic rays activate the rich chemistry that is observed in a molecular cloud and they also regulate its collapse timescale, determining the efficiency of star and planet formation, but they cannot penetrate up to the densest part of a molecular cloud because of energy loss processes and magnetic field deflections. Recent observations towards young protostellar objects show a surprisingly high value of the ionisation rate, the main indicator of the presence of cosmic rays, as well as synchrotron emission, the typical feature of relativistic electrons. Nevertheless, the origin of these signatures peculiar to accelerated particles is still puzzling. Here we show that particle acceleration can be driven by shock waves occurring in protostars through the diffusive shock acceleration mechanism. Our results demonstrate the possibility of accelerating particles during the early phase of a proto-Solar-like system and can be used as the argument to support available observations. The existence of an internal source of energetic particles can have a strong and unforeseen impact over the stellar and planet formation process as well as on the formation of pre-biotic molecules.

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