COMPUTATIONAL STUDIES OF COSMIC RAY ELECTRON INJECTION

L. O'C. Drury (1), K. G. McClements (2), R. O. Dendy (2), S. C. Chapman (3), M. E. Dieckmann (4), P. Ljung (4) and A. Ynnerman (4)
(1) Dublin Institute for Advanced Studies, Dublin 2, Ireland, (2) EURATOM/UKAEA Fusion Association, Culham Science Centre, Abingdon, OX14 3DB, UK, (3) University of Warwick, Coventry, CV4 7AL, UK, (4) Institute of Technology and Natural Science, Linköping University, Campus Norrköping, 601 74 Norrköping, Sweden.
`ld@cp.dias.ie`/Fax: +353-1-6621477

Observations of synchrotron radiation across a wide range of wavelengths provide clear evidence that cosmic ray electrons are accelerated to relativistic energies in supernova remnants (SNRs). It is widely accepted that these observations can be interpreted in terms of diffusive shock acceleration. However, the search for a viable pre–acceleration mechanism to mildly relativistic energies (the injection problem) remains an active field of research. Here we present computational studies which show acceleration of electrons from background energies to tens of keV. We use an electromagnetic particle–in–cell (PIC) code, with parameters appropriate for quasi–perpendicular collisionless shocks in SNRs. Free energy for electron energization is provided by ions reflected from the shock front, with speeds perpendicular to the magnetic field greater than the upstream electron thermal speed. Large amplitude electrostatic waves, excited initially via a two–stream instability at a single wave number, saturate when a large fraction of the electron population is trapped by them: a power law wavenumber spectrum eventually results. During this process electrons are accelerated to speeds greatly exceeding those of the shock–reflected ions producing the initial instability. Electron energization takes place through various resonant and non–resonant processes, of which the strongest involves stochastic wave–particle interactions. In SNRs the diffusive shock process would then supply the final step required for the production of fully relativistic cosmic ray electrons.