Electron acceleration and maser radiation from collisionless shocks

R. Bingham[1,2], D.C. Speirs[1], K. Ronald[1], A. Rigby[3], R. Bamford[2,3], R. A. Cairns[4], A.D.R. Phelps[1], M. E. Koepke[5], B. J. Kellett[2], L. O. Silva[6], S. Lebedev[7], G. Gregori[3]

[1]*Department of Physics, SUPA, University of Strathclyde, Glasgow, G4 0NG, U.K.*

[2]*Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, England, OX11 0QX, U.K.*

[3]*Department of Physics, University of Oxford, Parks Road, Oxford, OX1 3PU, U.K.*

[4]*School of Mathematics and Statistics, University of St. Andrews, Fife, Scotland, KY16 9SS, U.K.*

[5]*Department of Physics, West Virginia University, Morgantown, WV 26506-6315, U.S.A.*

[6]*GoLP/Instituto de Plasmas e Fusau Nuclear, Instituto Superior Tecnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal*

[7]*Imperial College London, London, SW72AZ, U.K.*

In this paper we describe a model of electron energization and cyclotron-maser emission applicable to astrophysical magnetised collisionless shocks. It is inspired by the work of Begelman, Ergun and Rees [1] who argued that the cyclotron maser instability occurs in localised magnetised collisionless shocks such as those expected in Blazar jets. We report on two recent laboratory experiments and numerical simulations carried out to investigate electron acceleration at collisionless shocks and the maser radiation mechanism [2][3][4]. We describe how electrons accelerated by lower-hybrid waves at collisionless shocks generate cyclotron-maser radiation when the accelerated electrons move into regions of stronger magnetic fields. Magnetic compression and conservation of magnetic moment lead to the formation of an electron velocity distribution having a horseshoe shape as the electrons are accelerated along the magnetic field. Under certain conditions the horseshoe electron velocity distribution is unstable to the cyclotron maser instability. Electron ring distributions are also unstable to cyclotron maser emission and we show that such distributions can also be generated at collisionless magnetised shocks.

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