P 17: Astrophysical Plasmas

Time: Thursday 14:00–15:15 Location: P-H11

P 17.1 Thu 14:00 P-H11

Electron acceleration at supernova remnants — •Artem Bohdan — Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany

Supernova remnants (SNRs) are believed to produce the most part of the galactic cosmic rays (CRs). SNRs harbor non-relativistic collisionless shocks responsible for acceleration of CRs via diffusive shock acceleration (DSA), in which particles gain their energies in repetitive interactions with the shock front. As the DSA theory involves pre-existing mildly energetic particles, a means of pre-acceleration is required, especially for electrons. Electron injection remains one of the most troublesome and still unresolved issues and our physical understanding of it is essential to fully comprehend the physics of SNRs. To study any electron-scale phenomena responsible for pre-acceleration, we require a method capable of resolving these small kinetic scales and Particle-in-cell (PIC) simulations fulfill this criterion. Here I report about the latest achievements on kinetic simulations of non-relativistic high Mach number shocks. I discuss how the physics of SNR shocks depends on the shock parameters (e.g., the shock obliquity, Mach numbers, the ion-to-electron mass ratio), which processes are responsible for the electron pre-acceleration and how these shocks can be studied using in-situ satellite measurements. Finally, I outline future perspectives of the electron injection problem and other complementary ways to solve it.

P 17.2 Thu 14:15 P-H11

Suppression of the TeV pair-beam plasma instability by a weak intergalactic magnetic field — •Mahmoud Alawashra[1] and Martin Pohl[1,2] — [1]Institute for Physics and Astronomy, University of Potsdam, D-14476 Potsdam, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany

We constrain the intermediate-scale intergalactic magnetic field (IGMF) through its suppression of the electrostatic instability for blazar-induced pair beams. IGMF of femto-Gauss strength are sufficient to significantly deflect the TeV pair beams, which reduces the flux of secondary cascade emission below the observational limits. A similar flux reduction may result from the electrostatic beam-plasma instability, which operates the best at zero IGMF. We study the effect of sub-fG level IGMF on the electrostatic instability of the blazar-induced pair beam. Considering IGMF with correlation lengths smaller than a few kpc, we find that such fields increase the transverse momentum of the pair beam particles, which dramatically reduces the linear growth rate of the electrostatic instability and hence the energy-loss rate of the pair beam. Our results show that the IGMF eliminates the beam-plasma instability as an effective energy-loss agent at a field strength three orders of magnitude below that needed to suppress the secondary cascade emission by magnetic deflection. For intermediate-strength IGMF, we do not know a viable process to explain the observed absence of GeV-scale cascade emission.

P 17.3 Thu 14:30 P-H11

Analysis of Ball Lightning observations aiming at an experimental verification — •Herbert Boerner — Mainz

Ball Lightning (BL) is still an unexplained phenomenon of atmospheric physics. There is no accepted theory explaining it, and there are no experiments that produce such objects in a laboratory. The only evidence available is through reports by accidental observers. In order to make progress in selecting theories that are consistent with the observations and in defining suitable experiments, it is important to select from the thousands of anecdotal reports those that are both reliable and that contain information on the physics involved. With this in mind, the following reports and properties will be considered: properties of BL objects that have been recorded consistently over many years, single, very well documented events, and individual reports by reliable observers. The first result is that Bl objects cannot be based on matter, they have to be a form of electromagnetic radiation. This conclusion is motivated by the fact that they can pass through dielectric objects like glass panes, and that they can move with velocities higher than the speed of sound. There are indications, that positive cloud-ground lightning (+CG) has a much higher probability to create these objects that negative CG lightning. Together with the fact that BL objects can be produced far away from lightning channels, this allows a rather good definition of the conditions under which such objects can be created. The importance of some properties of negative corona in air, mainly of Trichel pulses, and the role of free electrons is highlighted and an experimental setup is proposed.

P 17.4 Thu 14:45 P-H11

PIC simulations of SNR's shock waves with a turbulent upstream medium — •Karol Fułat[1], Martin Pohl[1,2], Artem Bohdan[2], and Paul Morris[2] — [1]Insitute of Physics and Astronomy, University of Potsdam, 14476 Potsdam, Germany — [2]DESY, 15738 Zeuthen, Germany

Investigation of astrophysical shocks has a major importance in understanding physics of the cosmic rays acceleration. Electrons to be accelerated at shocks must have an injection energy, which implies that they should undergo some pre-acceleration mechanism. Many numerical studies examined possible injection mechanisms, however most of them considered homogenous upstream medium, which is unreal assumption for astrophysical environments. We will to investigate electron acceleration at high Mach number and low plasma beta shocks using 2D3V particle-in-cell simulations with a turbulent upstream medium. Here we discuss the method of the generation of the compression-dominated turbulence and its quasi-seamless insertion into the upstream medium in the shock simulation. The modelled turbulence is sufficiently long-lived, and its parameters represent the high-Mach-number and low-beta regime.

P 17.5 Thu 15:00 P-H11

Pre-acceleration in the Electron Foreshock: Electron Acoustic Waves — •Paul Morris[1], Artem Bohdan[1], Martin Weidl[3], and Martin Pohl[1,2] — [1]Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany — [2]Institute of Physics and Astronomy, University of Potsdam, D-14476 Potsdam, Germany — [3]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, DE-85748 Garching, Germany

To undergo diffusive shock acceleration, electrons need to be pre-accelerated to increase their energies by several orders of magnitude, else their gyro-radii are smaller than the finite width of the shock. In oblique shocks, electrons can escape to the shock upstream, creating a region called the electron foreshock. To determine the pre-acceleration in this region, we undertake PIC simulations of oblique shocks while varying the obliquity angle. We show that while the proportion of reflected electrons is negligible for $\theta_{Bn} = 74.3°$, it increases to $R \sim 3\%$ for $\theta_{Bn} = 30°$, and that these electrons power electrostatic waves upstream with a wavelength around $2.5\lambda_{\rm se}$, where $\lambda_{\rm se}$ is the electron skin length. While the initial reflection mechanism is a combination of shock surfing acceleration and magnetic mirroring, once the electrostatic waves have been generated upstream they themselves can increase the momenta of upstream electrons parallel to the magnetic field. In $\lesssim 1\%$ of cases, upstream electrons are turned away from the shock and never injected downstream. In contrast, a similar fraction are re-directed back towards the shock after reflection and cross into the downstream.