

Particle Acceleration and Associated Emission from Relativistic Shocks

Five talks consist of a research program consisting of numerical simulations and theoretical development designed to provide an understanding of the emission from accelerated particles in relativistic shocks. The goal of this lecture is to discuss the particle acceleration, magnetic field generation, and radiation along with the microphysics of the shock process in a self-consistent manner. The discussion involves the collisionless shocks that produce emission from gamma-ray bursts and their afterglows, and producing emission from supernova remnants and AGN relativistic jets. Recent particle-in-cell simulation studies have shown that the Weibel (mixed mode two-stream filamentation) instability is responsible for particle (electron, positron, and ion) acceleration and magnetic field generation in relativistic collisionless shocks. 3-D RPIC code parallelized with MPI has been used to investigate the dynamics of collisionless shocks in electron-ion and electron-positron plasmas with and without initial ambient magnetic fields. In this lecture we will present brief tutorials of RPIC simulations and RMHD simulations, a brief summary of recent RPIC simulations, mechanisms of particle acceleration in relativistic shocks, and calculation of synchrotron radiation by tracing particles. We will discuss on emission from the collisionless shocks, which will be calculated during the simulation by tracing particle acceleration self-consistently in the inhomogeneous magnetic fields generated in the shocks. In particular, we will discuss the differences between standard synchrotron radiation and the jitter radiation that arises in turbulent magnetic fields.

May 15 – 25, 2009

May 18 – 22, 2009 (five 90-minute lectures)

Tentative synopsis

1. Basic Plasma Physics

- What is plasma?
- How they move?
- How dose it relate to this lecture?

2. Simulation Methods of Dynamics of Plasmas

- Fluid method
- Kinetic method
- Differences

3. GRMHD simulations

- Jet formation

Jet propagations

4. Kinetic (RPIC) simulations

Weibel instability, magnetic field generation, particle acceleration
Recent simulations

5. Radiation from Accelerated Particles

Synchrotron radiation
Standard emission models
Jitter radiation