Poster session 1
Wednesday May 15

• *Alexis Marret (LERMA)*

Kinetic study of the non-resonant streaming instability

The non-resonant streaming instability is believed to be the source of large magnetic field fluctuations in the context of supernova remnants shocks, and it is a candidate to explain the observed energy spectrum of cosmic rays. In this work we aim to study the instability dynamics and fundamental mechanisms, as well as the magnetic field growth rate and saturation level, as a function of the temperature of the ambient medium. A kinetic approach of the instability is used, completed with Hybrid-PIC simulations considering the electrons as a mass-less fluid and the ions as macro-particles. We depict several essential features of the non-resonant mode, such as the spatial structure, velocity dynamic, magnetic field spectrum evolution, ions heating, and scattering of the streaming ions. We find that, because of important resonant interactions, the magnetic field growth rate and saturation level can be reduced by up to 50% with increasing ambient temperature, for the range of parameters considered. Kinetic effects are thus important, and the use of MHD modelling should be considered with great care.

• *Giancarlo Mattia (Max-Planck-Institut für Astronomie)*

A constrained transport method for the solution of Resistive Relativistic plasmas in the PLUTO code

Resistive plasmas are of fundamental importance in the description of physical phenomena such as magnetic reconnection, which has been recently pointed out as an efficient site for particle acceleration. Here we present a new module for the PLUTO code that solves the Relativistic Resistive MagnetoHydroDynamics (RRMHD) equations using an IMplicit-EXplicit Runge-Kutta (IMEX-RK) method for the evolution of the electric field. The divergence free condition and the conservation of the electric charge are treated using a constrained transport method, where both electric and magnetic fields have a staggered representation. The solution of the Riemann problem is obtained under the frozen limit condition on the direct combination of two Riemann solvers: one for the outermost electromagnetic waves across which only transverse components of electric and magnetic fields can change, and a second one across the sound waves where only hydrodynamical variables have non trivial jumps.

• *Eszter Dudas (Institut de Physique de Rennes)*

The Platypus exoplanet project

Our objective is to produce laboratory astrophysics infrared spectroscopic data of small hydrocarbons which are required for modelling hot Jupiter type exoplanet atmospheres in the 1000 - 2500 K temperature range. The high-temperature plasma plume generated by the Platypus source (prototype developed by SP3 (ANU)), will be probed using the ultrasensitive cavity ring-down spectrometer (CRDS) implemented at DPM (UR1). In the out-of-equilibrium supersonic plasma, rotational and vibrational temperatures are strongly decoupled. The high vibrational temperature (> 1000 K) is suited for the investigation of highly excited molecular vibrational energy levels whereas the very low rotational temperature (~10 K) leads to a drastic rotational line decongestion that simplifies the spectral analysis. This poster presents the experimental setup and the preliminary results of the flow characterisation.

• *Alisa Galishnikova (Moscow Institute of Physics and Technology)*

Simulations of the light curves of an orthogonal radio pulsar

The recently-constructed theory [1] of radio wave propagation in pulsar magnetosphere outlined the general aspects of the radio light curve and polarization formation. It allowed us to describe general properties of mean profiles, such as the position angle of the linear polarization, p.a., and the circular polarization for the realistic structure of the magnetic field in the pulsar magnetosphere. In this poster we present application of our theory to the radio observations of PSR J1906+0746 (M. Kramer, private communication). This pulsar is particularly interesting because observations of relativistic spin-precession in a binary system allowed to put strong constraints on the geometry of the pulsar. The fact that pulsar is a nearly orthogonal rotator allowed to observe both magnetic poles, which as we show is crucial for testing our theory and obtaining constraints on the parameters of magnetospheric plasma. Our results show that plasma parameters are qualitatively consistent with theories of pair plasma production in polar cap discharges. [1] Beskin V.S., and Philippov A.A., 2012, MNRAS, 425, 814

• *José Ortuño-Macías (CAMK)*

Kinetic Simulations of Relativistic Radiative Steady-State Magnetic Reconnection

We investigate non-thermal particle acceleration mechanisms in relativistically magnetized astrophysical environments, e.g., pulsar wind nebulae or relativistic jets of blazars. We will present the results of kinetic simulations of relativistic magnetic reconnection in a domain with open boundaries including synchrotron radiation reaction (based on the PIC code Zeltron). The product of such steady-state simulations is a chain of plasmoids that trap most of the energetic particles in closed magnetic loops (Sironi et al. 2016). The stochastic distribution of physical parameters of the plasmoids has been shown, by coupling the PIC simulations results with semi-analytical radiative transfer, to be able to explain the multi-wavelength and multi-timescale lightcurves of high energetic astrophysical sources (Christie et al. 2018). We will discuss the effects of radiative cooling on the distributions of plasmoid properties and the resulting self-consistent signals of synchrotron radiation. We will show that in the case of high radiation efficiency, most of the energy of smaller plasmoids can be radiated away within the simulation domain.

• *Evan Heintz (University of Wisconsin-Madison)*

The Effect of Cosmic Ray Transport on Galaxy Evolution

I will present work on a linear stability analysis of the Parker Instability, as well as work being done on an Eddington limit for cosmic rays. The Parker Instability is a Rayleigh-Taylor like mode where the magnetic field and cosmic rays support the thermal gas against gravity. Instability occurs when a perturbation to the magnetic field causes the field lines to bend, allowing gas to slide down into the valleys of the field and release gravitational potential energy, which destabilizes the system. Cosmic rays play an important role in feedback processes, although their impact depends on the model of cosmic ray transport one uses. In galactic disk models, if the cosmic rays only advect with the gas, they create a stable, puffed-up disk that is cosmic ray supported. However, one could assume that instead of advecting with the gas, the cosmic rays stream at the Alfvén speed, a consequence of gyroresonant scattering between cosmic rays and Alfvén waves which heats the gas via wave damping. In this model, the galactic disk becomes thinner and galactic winds are more easily launched. Therefore, a correct implementation of cosmic ray transport in any astrophysical system is important in determining the effects of cosmic rays on their surrounding environment. Galactic disk models with only cosmic ray advection seem stable at the resolution studied. However, these systems can be susceptible to the Parker Instability. To determine if the puffed-up disk is truly stable, we examined three different cases of the Parker Instability: decoupled (, coupled with but no streaming, and coupled with streaming. When the compressibility of the cosmic rays decreases, the system becomes more stable, but the addition of cosmic ray streaming is extremely destabilizing due to the cosmic ray heating of the gas. These results indicate that these puffed-up galactic disks are most likely stable, but they also indicate that cosmic ray streaming is an important aspect of cosmic rays that should be considered when building models. Further work has also been done to implement radiative cooling and a smooth gravitational potential. The increased instability we found in our Parker analysis has led to further questions about the role of cosmic rays in sculpting their own environment. Specifically, we wish to determine if there is an Eddington limit for cosmic rays. If cosmic rays are able to reach this Eddington limit, they will be able to drive galactic winds and quench star formation. Cosmic ray streaming provides a way for cosmic rays to efficiently transfer energy and momentum to the surrounding medium which should allow them to drive outflows more easily. However, their ability to do this will largely depend on whether they can overcome energy losses from processes like ion-neutral friction, which can prevent cosmic rays from heating the gas, and pion production. Therefore, I will present on the initial work we are doing to examine the possibility of this Eddington limit for cosmic rays and whether it is a realistic threshold which cosmic rays can reach.

• *Nadia Biava (Università di Bologna)*

MS 0735.6+7421: new radio data

I will present new radio data of MS 0735.6+7421 (hereafter MS0735), a galaxy cluster located at z = 0.22, which presents giant cavities and shock fronts, caused by an interaction between a radio source and the hot gas surrounding it. The hot and densest gas at the centres of galaxy clusters should cool and fuel star formation in central galaxies at rates of tens to hundreds of solar masses per year (Fabian 1994). However, X-ray observations revealed far less cooling than expected, so the gas must be heated to and maintained at temperatures above ~2keV (Fabian et al. 2001). The most promising heating mechanism is feedback from the central active galactic nucleus (AGN)(reviewed by McNamara & Nulsen 2007). Outbursts from the central AGN inflate bubbles with radio emission, that are visible as cavities in X-ray imaging, and heat the intracluster medium. Radio jets launched by central AGN also drive shock fronts into the gas. Studyng MS0735 X-ray and radio data, McNamara et al. (2005) discovered giant cavities, each roughly 200kpc in diameter, filled with the synchrotron emission from the radio jet. A weak but powerful shock front encompasses the cavities. The total energy required to inflate the bubbles and drive the shock front exceeds 10^61 erg, making this the most powerful AGN outburst known. The data I will present cover different frequency bands: from 350 MHz to 8 GHz for the VLA data I found in the archive, observed using different array configuration, permitting to study both the large and the small scales. This variety of observations permits to estimate the radiative age of the source, from the calculation of the spectral index at the different frequencies, and to better understand its enigmatic nature.

• *Karen Pommois (Max Planck Institut fur Plasmaphysik)*

Hybrid driftkinetic electrons and kinetic ions implementation for electrostatic fluctuations in weakly magnetized collisionless plasmas in space and laboratory

Kinetic numerical simulations, applied to study local heating in the solar wind, are computationally expensive due to the different evolution scales involved in the dynamics. Therefore, simplified models, such as hybrid fluid-kinetic and gyrokinetic, are widely employed. However, gyrokinetics is missing waves with frequencies above the cyclotron frequencies of the species involved and the hybrid-fluid model is missing electron kinetic effects, which can be important even at ion scales (Told et al., New J. Phys. 2016). Therefore, a more suitable and computationally lighter model to investigate kinetic effects in astrophysical plasma simulations could employ a hybrid description, composed of kinetic ions and gyrokinetic electrons. In this poster we will show our first numerical steps, where we implemented this hybrid model in the case of electrostatic dynamics and drift-kinetic electrons. The distribution functions are evolved through semilagrangian schemes separately for ions and electrons and coupled through the field, evolved using a domain decomposition method and an iterative scheduled relaxation method (Yang and Mittal, J. Comput. Phys. 2014). This hybrid model will be included in MuPhy (Lautenbach and Grauer, Front. Phys. 2018), a framework designed to couple different models for solving large scale plasma problems.

• *Jan Kotek (Astronomical Institute of the Czech Academy of Sciences)*

3D Magnetohydrodynamical Simulations Using Finite Element Method

The poster is about solving of multiscale problems in space and astrophysical plasma physics such as a magnetic reconnection and a development of magnetic fields in Solar atmosphere. Resistive MHD can be a good approximation capable to fill a gap between particle simulations and observed large-scale structures, especially when solved using Finite Element Method (FEM). Among advantages of the very general method is the possibility to approximate a solution using non-trivial functions such as divergence free functions for magnetic field on naturally nonuniform mesh with discontinuous physical quantities. We use numerical library DEAL.II and Discontinuous Galerkin FEM to demonstrate this approach in both 2D and 3D and with an adaptive mesh refinement. We show results of several tests including Titov-Demoulin equilibrium and stability of current sheet.

• *Egor Novoselov (Moscow Institute of Physics and Technology)*

Orthogonal pulsars as a key test for pulsar evolution

At present, there are theoretical models of radio pulsar evolution that predict both the alignment, i.e. evolution of the inclination angle χ between magnetic and rotational axes to 0° and its counter-alignment, i.e. evolution to 90°. At the same time, all these models describe well enough the pulsar distribution on the P-Pdot diagram. As no one still know how to determine the evolution of the inclination angle χ for individual pulsar, the braking mechanism remains unknown till now. Here we show how the statistics of interpulse pulsars can give us the test to solve the alignment/counter-alignment problem as the number of interpulse pulsars drastically depends on the evolution law.