EP 4: Numerische Modellierung

Time: Tuesday 16:30–19:15 Location: V55.02

Invited Talk EP 4.1 Tue 16:30 V55.02

Modern Numerical Tools For Astrophysical Problems — •Mario Flock — CEA, Paris, Frankreich

The development of modern numerical tools enable us to study several astrophysical problems. In recent years especially Godunov schemes with an approximate Riemann solver have become quite important for detailed investigations of supersonic flows as they are present in jets or even in young protoplanetary disks. I will present and discuss the methods used in the Godunov code PLUTO and show results of state-of-the-art 3D MHD stratified simulations of accretion disks.

Invited Talk EP 4.2 Tue 17:00 V55.02

Gyrokinetic Simulations of Plasma Microturbulence with GENE: Numerics and Applications — •Tobias Görler[1], Tilman Dannert[1], Frank Jenko[1], Daniel Told[1], and Stephan Brunner[2] — [1]Max-Planck-Institut für Plasmaphysik, IPP-EURATOM Association, Garching, Germany — [2]École Polytechnique Fédérale de Lausanne, CRPP, Association Euratom-Confédération Suisse, CH-1015 Lausanne, Switzerland

A better understanding and modeling of plasma microturbulence is inevitable for the realization and optimization of future power plants based on nuclear fusion as the effect of the corresponding anomalous transport on the energy confinement time strongly obstructs a self-sustaining plasma burning by now. Dedicated theory approaches are typically based on gyrokinetics and require massively parallel numerical simulations. A corresponding and quite comprehensive implementation of the gyrokinetic Vlasov-Maxwell system of equations is given by the software package GENE. The presents contribution aims at providing insights in the underlying numerical schemes, the parallelization techniques and physical approaches which, for instance, take advantage of the strong anisotropy of the turbulent structures in magnetic confined fusion plasmas. Particular emphasis will be given to the most recent extensions towards a full-torus and a full-flux surface code which allows for the investigation of finite size effects in small devices and steep gradient regimes. Furthermore, the capability of including self-consistent parallel magnetic fluctuations will be demonstrated as this feature extends the application range even to astrophysical problems.

EP 4.3 Tue 17:30 V55.02

Randeffekte bei der Simulation der Filamentierungsinstabilität — •Patrick Kilian, Urs Ganse und Felix Spanier — Lehrstuhl für Astronomie, Universität Würzburg, Deutschland

Etliche Klassen an astrophysikalischen Objekten zeigen starke relativistische Jets. Diese wechselwirken mit dem umgebenden Hintergrundmedium. In der Interaktionsregion durchströmen sich effektiv zwei kollisionsfreie Plasmen, eine Situation die instabil gegenüber Filamentierung ist. Da die Jets für astrophysikalische Fragestellungen wie die Entstehung der hochenergetischen kosmischen Strahlung interessant sind besteht Interesse an der Mikrophysik dieser Filamentierungsregionen.

Zur Simulation der kollisionsfreien Plasmen eigenen sich Particle-in-Cell-Codes. Diese können aufgrund der verfügbaren Rechenleistung jedoch nicht den ganzen Jet simulieren sondern nur herausgegriffene Modellregionen.

Die Wahl der Randbegingungen hat dabei Einfluß auf die Entwicklung der Filamentierungsinstabilität. Zu geringe Ausdehnung der Simulationsbox führt selbst bei periodischen Randbedigungen - genau wie die Beschränkung auf zwei Dimensionen - zu numerischen Artefakten.

EP 4.4 Tue 17:45 V55.02

Transition between different anomalous diffusion regimes in charge-fluctuating dusty plasmas — •Andreas Kopp[1] and Yuri A. Shchekinov[2] — [1]IEAP, Christian-Albrechts-Universität zu Kiel, 24118 Kiel, Germany — [2]Department of Space Physics, Southern Federal University, Rostov on Don, 344090, Russia

We present simple numerical simulations of random walks in a magnetized dusty plasma, in which we treat the dust as test particles in a 2D configuration with a magnetic field perpendicular to this plane. The diffusive aspect is brought in by randomly changing the parameters governing the resulting paths. Applying this to the dust charge we study the perpendicular diffusion for different values of the ratio of the time-scale for recharging to that for gyration. Increasing this single parameter in our simulations we observe for the first time a transition from subdiffusion via a wide plateau of normal or quasidiffusion to superdiffusion in the same configuration. The crucial point here is that when the recharging time is long there are phases of the dust motion, in which the particles are uncharged and, thus, can perform “ballistic” lights. On the other hand for short recharging dust grains are more tightly coupled to the magnetic field and therefore the random motions are supressed.

EP 4.5 Tue 18:00 V55.02

New Perspectives on Numerics for Stochastic Differential Equations and their Application to Energetic Particle Transport — •Frederic Effenberger[1], Horst Fichtner[1], Ingo Büsching[1], Andreas Kopp[2], and Robin Stern[1] — [1]Ruhr-Universität Bochum, Bochum, Germany — [2]Christian-Albrechts-Universität zu Kiel, Kiel, Germany

During the last decade Stochastic Differential Equations (SDEs) have become a viable numerical tool in space physics, in particular for the modeling of Cosmic Ray (CR) transport processes. Their application ranges from detailed calculations of solar energetic particle events to the CR transport in the Heliosphere and in the Galaxy. At the heart of the applicability of SDEs to CR diffusion is the fundamental equivalency between the parabolic Fokker-Planck type transport equation and SDEs involving Wiener processes to represent the stochastic Brownian motion of pseudo particles (phase space elements). In recent years, this equivalency has been extended to more general anomalous diffusion processes with different scalings between temporal and spatial displacements, leading to Fokker-Planck equations of fractional order and generalized probability distributions in the respective SDEs. We will present numerical tests and applications of this approach to anomalous diffusion, concerning the fractional derivatives in the Fokker-Planck equations as well as the equivalent formulation with SDEs, including technical aspects like the speedup by using graphic processing units (GPUs).

EP 4.6 Tue 18:15 V55.02

PIConGPU - Bringing a GPU-driven PIC code to large machines — •Michael Bussmann[1], Heiko Burau[1], René Widera[1], Axel Hübl[1], Alexander Debus[1], Thomas Kluge[1], Ulrich Schramm[1], Thomas E. Cowan[1], Felix Schmitt[2], Guido Juckeland[2], Wolfgang Nagel[2], Emmanuel d'Humières[3], Patrick Kilian[4], Urs Ganse[4], Stefan Siegel[4], and Felix Spanier[4] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]ZIH, Technische Universität Dresden — [3]CELIA Université Bordeaux 1 — [4]Lehrstuhl für Astronomie, Universität Würzburg

We present recent results on PIConGPU, a charge-conserving 3D relativistic particle-in-cell code running on graphic processors. We discuss best practices on how to implement the particle-in-cell algorithm on this new hardware and run it on large GPU clusters. We show that these codes have become mature enough to be considered for real life applications, delivering fast response time even for large physical problems.

EP 4.7 Tue 18:30 V55.02

Validierung und Erweiterung der Simulation radioaktiver Zerfälle mit Geant4 — •Steffen Hauf[1], Markus Kuster[2], Dieter H. H. Hoffmann[1], Stephan Neff[1], Maria Grazia Pia[3], Georg Weidenspointner[4,5], Andreas Zoglauer[6] und Zane W. Bell[7] — [1]TU Darmstadt, Darmstadt, DE — [2]European XFEL GmbH, Hamburg, DE — [3]INFN Sezione de Genova, Genova, IT — [4]Max Planck Halbleiter Labor - HLL, München, DE — [5]Max Planck Institut für Extraterrestrische Physik- MPE, Garching, DE — [6]University of California - Space Science Laboratory, Berkeley, USA — [7]Oak Ridge National Laboratory, Oak Ridge, USA

Für die kommenden Generationen hochsensitiver Weltraumteleskope, als auch für die bemannte Raumfahrt, sowie bodengestützte medizinische Anwendungen, kann eine korrekte Abschätzung der Einflüsse radioaktiver Strahlung, unter Umständen verursacht durch die Aktivierung von passivem Umgebungsmaterial, von großer Wichtigkeit sein. Oftmals werden diese Abschätzungen unter Zuhilfenahme von Monte-Carlo Tool-kits, wie z.B Geant4 getroffen. Eine vorhergehende Validierung an selbst-konsistenten Experimenten ist hierbei vorteilhaft.

Wir präsentieren solche Messungen an einem HPGe-Detektor, die im Rahmen unsere Hintergrundabschätzungen für den Wide Field Imager des ATHENA Röntgenteleskops durchgeführt wurden. Im Rahmen dieser Arbeit wurde außerdem die Simulation radioaktiver Zerfälle in Geant4 erweitert, so dass die Auswirkungen der Langzeitaktivierung von Satellitenkomponenten auf den Detektorhintergrund abgeschätzt werden können.

EP 4.8 Tue 18:45 V55.02

Fundamentale Limitierungen des Particle in Cell-Ansatzes - Dinge, die mit PiC einfach nicht gehen. — •Felix Spanier, Urs Ganse, Andreas Kempf, Patrick Kilian, Cedric Schreiner und Stefan Siegel — Lehrstuhl für Astronomie, Universität Würzburg

Particle in Cell Codes sind etablierte Mechanismen zur numerischen Modellierung kollisionsfreier Plasmen. Die gestiegene Popularität dieses Ansatzes in den letzten Jahren führt zu seiner Verwendung in Simulationsszenarien, die die funadmentalen Limitierungen klassischer PiC-Codes herausfordern.

Dieser Talk geht exemplarisch auf einige Phänomene kinetischer Plasmen in astrophysikalischen Anwendungen ein, an denen nicht-spezialisierte PiC-Codes (auf offensichtliche oder nicht-triviale Weise) scheitern. Für einige dieser Prozesse zeigen wir Lösungsstrategien oder alternative numerische Ansätze.

EP 4.9 Tue 19:00 V55.02

Adaptive phase space simulation of relativistic QED plasma — •Nina Elkina — LMU, Munich

Kinetic modeling of relativistic plasma with proper accounting for quantum effects is a challenging task which arises in astrophysics. Collective effects in such plasma are governing high energy processes around highly magnetized compact rotating stars, merging black holes, jets from active galactic nuclei. As laser intensities increase, quantum electrodynamic effects in plasma pair production will become increasingly important and ultimately dominant in laboratory conditions.

A central problem simulating of relativistic plasma with essential QED effects is the need for a proper model for radiation, which would simultaneously account for both classical radiation responsible for collective emission and noncoherent hard photons. In order to solve on the computer the kinetic equations for QED plasma we adopt the particles-in-cell method coupled with Monte-Carlo procedure for quantum effects. This method requires huge computational power and memory due to high dimensionality of the problem and sometimes simply not feasible within a brute force approach. In order to circumvent this barrier we use an adaptive phase space refinement technique to keep a number of numerical quasi-particles per cell approximately constant while a number of real particles can increase or decrease rapidly due to QED effects. Adaptive refinement in phase space brings a new capability to represent the subtle dynamics in the phase space which a critical issue for study of gamma and X radiation sources sources in laboratory as well as in astrophysical conditions.