**FINAL REPORT ON THE 4-WEEK PROGRAMME**

**GYROKINETICS IN LABORATORY AND ASTROPHYSICAL PLASMAS**

(INI, 19 July – 13 August, 2010)

Organisers: W. Dorland (Maryland), S. Nazarenko (Warwick), A. Schekochihin (Oxford)

**Motivation for the Programme.** The physical motivation for the programme was the challenge of understanding plasma turbulence (and, more generically, kinetic turbulence). While the problem is long-standing, it is made particularly timely by a number of relatively recent developments: the start of the ITER project for fusion plasmas, unprecedented amount of data on small-scale plasma fluctuations becoming available through modern measurement techniques in the laboratory and in the solar wind, radical increase in computing power making fully resolved 3D kinetic simulations finally feasible, and substantial progress in understanding due to recent theoretical advances. Gyrokinetic theory has emerged as the theoretical framework of choice in both fusion plasmas and, increasingly, in space plasmas, as it offers a rigorous route to reducing the dimensionality of the kinetic phase space and the timescale range that must be handled by mind or computer. The gyrokinetic approximation (and, as has emerged during the Programme, especially the aspect of it that deals with the coupling between fluctuation scales and transport scales) does, however, pose a number of mathematical problems – ranging from nearly pure mathematical ones (well-posedness of the equations) to very practical (efficient numerical methods). The idea of the Programme was to address the problems of plasma turbulence, its numerical modelling and its gyrokinetic description by bringing together a very broad an interdisciplinary group of experts: from experimentalists and observers to numerical modellers, plasma theorists and applied mathematicians.

**Programme structure, topics covered.** During the first week (19-23 July 2010) a workshop was held, “Kinetic-scale turbulence in laboratory and space plasmas: empirical constraints, fundamental concepts and unsolved problems,” organised by S. Bale (Berkeley), T. Carter (UCLA), W. Dorland (Maryland), S. Nazarenko (Warwick), and A. Schekochihin (Oxford). A number of additional participants and invited speakers attended. The idea of the workshop was to set the stage by fixing the range of empirical facts and the challenges to modelling understanding that they pose.

In the three weeks that followed, the standard mode of operation was to hold two seminars a day: one in the morning and one after lunch. In addition, there were six special one-day or half-a-day workshops:

1. *Kinetic reconnection* (full day in week 2). Organisers: N. Loureiro (Lisbon), A. Schekochihin (Oxford), D. Uzdensky (Boulder). 26 July 2010
2. *Edge gyrokinetics* (half-day in week 2). Organiser: P. Catto (MIT). 27 July 2010
3. *Drift tearing and microtearing* (half-day in week 2). Organiser: N. Loureiro (Lisbon). 28 July 2010

The seminars, offline discussions and collaborations were structured around 11 working groups focused on specific problems:

1. Alpha particles, their transport and Alfvenic instabilities (moderator: I. Abel (Oxford))
3. Phase-space turbulence, energy flows in gyrokinetics (moderators: J. Krommes (Princeton) & G. Plunk (Maryland))
4. Edge gyrokinetics (moderator: P. Catto (MIT))
5. Global full-f simulations (moderator: F. Parra (Oxford))
6. Hamiltonian gyrokinetics (moderator: A. Brizard (St Michael's College))
7. Kinetic reconnection (moderators: N. Loureiro (IST Lisbon) & D. Uzdensky (UC Boulder))
8. Microtearing and high-beta gyrokinetics (moderators: N. Loureiro (IST Lisbon) & C. Roach (CCFE))
9. Sheared gyrokinetic turbulence, interactions between flows and turbulence (moderators: F. Casson (Warwick) & E. Highcock (Oxford))
10. Gyrokinetics for simple laboratory plasma configurations (moderator: P. Ricci (EPF Lausanne))
11. Tokamak transport (moderator: M. Barnes (Oxford))

Further information: see [http://www-thphys.physics.ox.ac.uk/research/plasma/ukgk.html](http://www-thphys.physics.ox.ac.uk/research/plasma/ukgk.html).

**Outcomes.** The Programme outcomes are best summarised by the publications that were, in various degree, inspired by it. The list, supplied by the participants, is attached. These represent, in a sense, the “measurable outcomes.” The less directly measurable but no less important ones are a new network of collaborations that have emerged (due to the interdisciplinary selection of the programme participants, for many this was the first time that they found each other attending the same scientific gathering) and the way in which the discussions held during the Programme have influenced the thinking of the community. It is perhaps symptomatic in less than year that has passed since the Programme, two other interdisciplinary events of this kind have been organised by the participants:

- “Dynamics and turbulent transport in plasmas and conducting fluids” (organised by N. Plihon et al. at Les Houches, February 28-March 11, 2011)
- “Vlasov-Maxwell kinetics: theory, simulations and observations in space plasmas” and “Fusion theory working group meeting” (organised by F. Califano and A. Schekochihin at Wolfgang Pauli Institute in Vienna, March 29-April 15, 2011)

While justice cannot be done within the space allocated to this Report to all the scientific discussions that took place during the Programme, the topics that received particular emphasis and so deserve special mention were

- Transport bifurcations in fusion plasmas and subcritically driven gyrokinetic turbulence
- Fast magnetic reconnection, plasmoid reconnection, gyrokinetic reconnection
- Momentum transport and energy conservation in gyrokinetic formalism and implications for numerical modelling
PUBLICATIONS
This is a list of papers (as supplied by the participants), both published and submitted, that were worked on/started/discussed/conceived/influenced/inspired by the discussions during the Programme.

Published


In press


Submitted