Nils Tångefjord Basse
E-mail: nils.basse@npb.dk
Homepage: www.npb.dk

Past research on magnetically confined fusion plasmas:

Postdoctoral research

Until the end of July 2005 I was a Postdoctoral Associate at the Massachusetts Institute of Technology (MIT). I was employed by the Plasma Science and Fusion Center to work on the Alcator C-Mod tokamak. My research focused on four topics:

1. Lower hybrid current drive [camera, control and data acquisition]
2. Reflectometry [measurements, upgrades, analysis]
3. Phase-contrast imaging [measurements, upgrades, analysis]
4. Small-angle scattering [analysis in collaboration with CAT-Science]

Although I initially came to MIT to work on the lower hybrid current drive (LHCD) installation, delays in that project lead me to simultaneously pursue my interest in turbulence.

Let me briefly sketch my activities during the two and a half years at MIT (I began as a Postdoctoral Associate 4th of November 2002):

1. The initial months were spent getting to know the C-Mod machine and learning how to run the various software programs necessary to look at and analyze plasma discharges. At the same time I began my first task, which was to create operator software for the LHCD system. It included making a widget based IDL program, creating a storage structure and data acquisition using compact PCI (cPCI) modules. Additionally, we installed a camera to monitor the launcher.

2. Around March-April 2003 I felt that I would like to contribute more directly to the immediate experimental objectives of the C-Mod group. In discussions with the Principal Investigators we agreed that I should take over the reflectometry measurements. This effort has since resulted in the successful initial operation of two new high frequency channels installed in collaboration with the Princeton Plasma Physics Lab (PPPL). An upgrade of the original system is scheduled to take place over the next few years and I supervised a graduate student (Arturo Dominguez) who is working toward this goal.

3. In parallel to this development I began to assist one of Miklos Porkolab's graduate students (Liang Lin) in getting the phase-contrast imaging (PCI) density fluctuation diagnostic operational. The student previously running PCI left MIT shortly thereafter, so Liang Lin and I fixed a number of hardware issues and managed to get useful data before the end of the first 2003 C-Mod campaign. An additional graduate student (Eric Edlund) joined the PCI team in the fall of 2003. Since his arrival we completed an extensive electronics and data acquisition upgrade to the PCI system. A second round of upgrades took place in 2005.

4. Finally, I spent time analyzing material from my Ph.D. project and writing papers.

Ph.D. research

First of July 2002 I obtained the Ph.D. degree in physics from the Niels Bohr Institute for Astronomy, Physics and Geophysics (Ørsted Laboratory) at the University of Copenhagen, Denmark. The work was done under the auspices of the Optics and Plasma Research Department at the Risø National Laboratory in Roskilde, Denmark.

My research focused on measurements of fluctuations in the electron density of Wendelstein 7 - Advanced Stellarator (W7-AS) plasmas. This was accomplished by a CO_2 laser based collective scattering diagnostic called localized turbulence scattering (LOTUS). During my Ph.D. studies I spent a total of two years at the Max-Planck-Institut für Plasmaphysik in Garching, Germany.

M.Sc. research

At the Joint European Torus (JET), I wrote my M.Sc. thesis on measurements of neutron emissivities using various techniques. Comparisons and modeling of the various diagnostics enabled me to make progress in understanding systematic discrepancies found between measurements. During my M.Sc. studies I spent one year at JET in Culham, England.

Qualifications

During my Ph.D. studies, I was fully responsible for the day-to-day operation of LOTUS, including spare part acquisition and installation, system upgrades, alignment of the optical components, analysis software et cetera. This gave me a large amount of hands-on experience in the complex field of fusion plasma diagnostics.

I made extended theoretical derivations in my Ph.D. thesis on scattering of infrared light off collective density fluctuations and on how to localize turbulence using two distinct methods.

I taught a class of undergraduate chemistry students at the University of Copenhagen in the fall of 2000. The course was on basic mathematics and involved solving problem sets in class and correcting written assignments. I learned a great deal about supervision by helping the two PCI graduate students with hardware and analysis aspects of the diagnostic. I also supervised the graduate student working on reflectometry.

While at JET I mainly gained experience in modeling (Fortran programming on an IBM mainframe), data analysis (using SAS and JET-specific analysis tools) and an overview of tokamak concepts and operational procedures. Further, I familiarized myself with the diagnostics delivering the measurements I modeled: The neutron profile monitor and charge exchange recombination spectroscopy.

Research interests

The unifying theme of my research interests is confinement transitions in fusion plasmas. Especially the interplay between turbulence, magnetic topology and confinement transitions studied using fluctuation measurements. I have investigated the role of electron transport and small-scale turbulence using both density, magnetic and H-alpha fluctuation measurements in W7-AS and Alcator C-Mod.

I. Confinement and magnetic topology

I am of the opinion that a larger effort should be concentrated on the exploration of the influence of magnetic topology, e.g. magnetic shear and rational q-surface positions, on global and local confinement. This area has been somewhat neglected due to the surge of interest in turbulence suppression by **E**×**B** shear and zonal flow generation. In W7-AS links between the q-profile, turbulence and confinement have been extensively analyzed.

The preceding paragraph leads me to my interest in comparative studies of turbulence and confinement transitions in stellarators and tokamaks. My experience with both concepts enables me to pursue the similarities and differences. I have conducted initial W7-AS similarity experiments in C-Mod during 2003-2004 to elucidate the influence of q-profile modifications on global and local confinement. This also connects to observations of electron thermal transport barriers made in the Rijnhuizen Tokamak Project. The similarity experiments are made in collaboration with Hungarian and German colleagues.

II. Theory and experiment

Recently, nonlinear numerical simulations have shown that electron transport can be significantly enhanced by radially elongated streamers formed due to electron temperature gradient (ETG) driven modes. A search for ETG modes was carried out in dedicated W7-AS discharges, but no sign of the instability was observed. However, the search should be continued in other fusion devices.

The search for ETG modes brings me to another subject I think is quite essential in fusion science: The comparison of quantitative theoretical predictions to plasma measurements.

From the experimental end one can model turbulent ‘events’ to simulate diagnostics in the actual geometry of a certain machine (a.k.a. ‘synthetic diagnostics’). This is currently being done for the LOTUS diagnostic by my Hungarian associates. Eventually one should use full-scale simulations to visualize measurements made by actual diagnostics.

Comparisons between PCI measurements and nonlinear gyrokinetic GS2 simulations have recently been carried out, showing quite good agreement. Further work is in progress, both to refine the PCI analysis and to make the GS2 output as similar to the PCI geometry as possible.

III. L-H transition
The low (L-) to high (H-) mode confinement transition also has my interest. I delved into that subject mainly using density and magnetic fluctuations in W7-AS. Cross correlating the various fluctuating fields gave additional insight into differences between L- and H-mode turbulence. Since C-Mod has a large set of fluctuation diagnostics I continued my L-H transition studies there.

IV. Density fluctuations on small and large scales
Intriguing observations of density fluctuations on astronomical scales (Mpc) might indicate that their dependence on wavenumber is similar to that of mm scale turbulence in fusion plasmas. The Mpc measurements are from the Sloan Digital Sky Survey (SDSS) and the fusion plasma measurements are from a collective scattering diagnostic on the W7-AS stellarator. As the C-Mod PCI diagnostic is upgraded to be sensitive to larger wavenumbers, these studies will be continued.

Research ideas

I. Scaling of turbulence with radiation and/or impurities
The W7-AS measurements indicated that density fluctuations scale better using radiated power instead of density.

II. Turbulence at the density limit
Is turbulence to blame for density limits?

III. Turbulence associated with natural islands in W7-AS
Earlier observations, e.g. using pulsed radar reflectometry, show that turbulence at the O- and X-points of islands associated with low-order rational surfaces is very distinct. Initial analysis showed that this might also be the case for natural islands in W7-AS.

IV. Possible link between the L-H transition and Earth systems
The bifurcation behavior of the L-H transition could be similar to the stick-slip nature of earthquakes. It would be interesting to apply existing Earth system models of earthquakes to the L-H transition.