An overview of my past and present research

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Abstract

This document contains a broad overview of my past and present research activities.

Part of my work for the companies ABB, Siemens and Danfoss is confidential and not published. Where relevant for my research, I will mention the topics but refrain from details.

1. Danfoss: Components for refrigeration and air conditioning

At Danfoss, I am a CFD Expert working in the Technology and Innovation Department which is part of the R&D organization.

The main product is thermostatic expansion valves. A large pressure drop occurs across these valves, leading to a transition from a single- to a two-phase fluid.

The activities closest to research are Technology Explorations, where we build up competencies in new fields. The goal is to be able to differentiate ourselves from competitors and offer new-to-the-world products. Currently, I am the project leader of such an exploration in the field of acoustics; this involves both experiments and simulations.

Another part of the job is CFD simulations for (i) new products and (ii) maintenance of existing products.

2. Siemens: Flowmeters

I was working as a Senior Research Engineer at Siemens. A list of my activities can be found here [1].

Concerning research, I had two major activities:

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1. Coriolis flowmeters
2. Pipe flow

2.1. Coriolis flowmeters

Coriolis flowmeters are often preferred for two-phase flow since they are performing well relative to other technologies such as ultrasonic or electromagnetic flowmeters.

However, Coriolis flowmeters suffer from both measurement errors and damping due to two-phase flow.

Based on the "bubble theory" of Dr. John Hemp [2], I have reviewed the predicted measurement errors [3]. The theory has been compared to measurements [4].

The damping of Coriolis flowmeters has been studied in [5]. We found that the damping theory can also be used to understand research relevant for the nuclear industry [6].

2.2. Pipe flow

In [7], we have investigated the mean velocity and turbulence intensity of pipe flow using a combination of measurements [8] [9], semi-empirical modelling [10] and CFD simulations [11].

Our goal was to document the scaling of turbulence intensity with Reynolds number - this had not been done before.

The study in [7] was for smooth-walled pipes; subsequently, I did private research on the turbulence intensity scaling for rough-walled pipes [12].

2.3. Non-published research work

- Flow conditioning in flow rigs using a combination of hole plates, swirl plates, orifice plates and contractions. Comparison of CFD simulations with measurements.

- Scaling of turbulence intensity for high-speed (up to Mach 0.8) gas flow in Coriolis flowmeters.

- The water hammer effect in flow rigs.

3. ABB: Circuit breakers

I was working as a Scientist (later, Principal Scientist) at ABB. A list of my activities can be found here [13].

3.1. Turbulent mixing

My main research topic was turbulent mixing studied using optical measurements [14, 15, 16] and compared to CFD simulations [17]. I also did some work on comparing measured and simulated pressure [18].

The optical measurements were a revival of work done at ABB in the seventies. The work had stopped, but optical components and low power HeNe lasers were available. It was a good opportunity for me to use the optics background I have from my Ph.D. and postdoc. A new CMOS camera was bought which was used as a detector. We built transparent circuit breaker models in PMMA. The camera measurements were used to track turbulent structures to extract the velocity field.

3.2. Non-published research work

- Modelling and optimization of systems using a combination of mechanics, thermodynamics and electromagnetic forces. Comparison to measurements.
- Measurements and simulations of current interruption performance.
- Measured pressure oscillations in different circuit breaker geometries.
- Schlieren imaging of vacuum interrupter arcs.
- Influence of nozzle geometry and contact material on current interruption performance.
- High temperature tests of pressure sensors.
- Arc dynamics.

4. Research on magnetically confined fusion plasmas

4.1. Postdoc

As a postdoc, my main activity was work on optical turbulence measurements using phase-contrast imaging (PCI). Measurements were made in the Alcator C-Mod tokamak which is situated on the MIT campus. I participated in upgrading the PCI diagnostic, including a new CO_2 laser and data acquisition system.

In parallel I began to upgrade the reflectometry diagnostic. As the PCI system, reflectometry also measures density fluctuations. From 2004, I began supervising a graduate student who took over the reflectometry diagnostic.

An overview of my work on the PCI and reflectometry systems can be found in [19].

My general interest in fusion diagnostics led to the review paper on the Alcator C-Mod tokamak diagnostic systems [20].

We used measurements from the PCI system to compare to gyrokinetic simulations made using GS2 [21]. A synthetic diagnostic was created to post-process the GS2 simulations and make a direct comparison of measurements and simulations. The trapped electron mode instability was predicted by GS2 and this reproduced the measurements quite well.

A more operational task during my stay at MIT was to develop a control system for the new lower hybrid current drive system being brought online. This also included work to setup a camera to observe the grill [22].

Finally, similarities between wavenumber spectra in fusion plasmas and on cosmological scales motivated me to pursue a cross-disciplinary activity: Density fluctuations on mm and Mpc scales [23, 24, 25]. For comparable work using laser plasmas, see [26] and references therein.

4.2. Ph.D.

As a Ph.D. student, I was working on optical turbulence measurements using collective scattering [27]. The measurements were made in the Wendelstein 7-AS stellarator at IPP-Garching [28].

The main reason for the work was to find connections between turbulence and plasma confinement; it is believed that turbulence plays an important part in the transport of energy and particles across the magnetic field confining the plasma.

Both spontaneous and controlled confinement transitions were studied, to a large extent using spectral analysis tools. The effort included cross-correlation between different turbulence diagnostics (e.g. magnetic and density fluctuations) and comparison of measured wavenumber spectra to the Kolmogorov theory of fluid turbulence [29, 30, 31, 32, 33].

I also wrote a review of the theory of collective light scattering [34].

At the time of my thesis, there was work on simulations of relevance to my experiments [35]. This was on electron temperature gradient driven instabilities which were predicted to exist at the very small scales measured by collective scattering.

4.3. M.Sc.

My work in fusion plasmas began at the JET tokamak at the Culham Science Centre in the UK.

There, I modelled neutron emissivities from the plasmas by comparing measurements from two diagnostics: Neutron measurements and charge exchange recombination spectroscopy [36]. The idea behind was to understand what was called the neutron discrepancy, i.e. differences in neutron production rates observed when cross-checking diagnostics.

During my studies I became involved in trace tritium experiments at JET [37, 38].

5. Astronomy

During my undergraduate studies, my two main projects dealt with astronomy.

My first year project was on the motion of the V1031 Orionis star system [39].

My bachelor thesis was written on the magnetic properties of the dust on Mars, specifically on systems installed on Mars Pathfinder [40].

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