IIP: Max Planck Institute for Dynamics and Self-Organization

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Göttingen, Germany
Turbulence: “the most important unsolved problem of classical physics” – Richard Feynman

Active grid: 129 independently-moving paddles in air flow

By changing how the grid moves, can we change how the turbulence downstream behaves?

Previous attempts were unable to induce turbulence changes

Our task: develop new algorithms to correlate grid motions in time, and evaluate their effects on turbulence decay

Worked with fellow Princetonian Kevin Griffin ‘17

Advisor: Dr. Greg Bewley, with help from visiting researcher Dr. Willem van de Water
Taking on Turbulence

Active grid

Wind tunnel in the Experimentierhalle

Ludwig Prandtl’s original tunnel design

Hot-wire anemometer mounted on traverse, inside the tunnel
Research Responsibilities

- Program new temporal correlations function into existing active grid control code (C++)
  - Debug, refactor, and optimize old code along the way
- Collect data in the wind tunnel using hot-wire probes
- Process data using new and existing MATLAB scripts
- Discuss problems, findings, and possible directions with our advisor
Learning about turbulence theory and experimental methods from experts in the field

Freedom to come up with and test our own ideas

Experiencing work atmosphere at a purely research-oriented institution in a different country

Working on a project whose results could significantly impact future active grid turbulence research worldwide
Discovering Deutschland

- Göttingen: “Die Stadt der Wissen schafft”
  - Home of several famous intellectuals (such as Gauss, Weber, Planck, Hilbert, Riemann, Barth, and the Brothers Grimm)
  - Produced 47 Nobel laureates

- Accommodations: MPIDS guest house
- City travel by bus, longer trips by train
Exploring Europe

Swiss Alps
Deutsches Museum, München
ICE trains in Göttingen

Vienna
Dresden
Swiss Alps
Deutsches Museum, München
ICE trains in Göttingen

Dresden
Deutsches Museum, München
ICE trains in Göttingen

Rothenburg ob der Tauber
Leipzig
Paris

Rothenburg ob der Tauber
Leipzig
Paris

Strasbourg
Prague

Strasbourg
Prague

Salzburg
Prague

Zugspitze
Heidelberg

Zugspitze
Heidelberg

MPIDS interns on the Kölner Dom

Mannheim
Strasbour

Mannheim
Strasbour

Berlin
Lucerne

Berlin
Lucerne

Standing wave on the Eisbach, München

Standing wave on the Eisbach, München
Conclusions and Contributions

- Our temporal correlation algorithms allow researchers to induce nontrivial changes in turbulence
- New calibration and temperature correction programs significantly reduce experimental error
- Our extensive data sets may yield greater insights into the fundamental nature of turbulence decay
- Organized and documented code and procedures to soften the learning curve for future researchers
Career Consequences

- Learned new programming skills and gained vital experience with experimental work
- Continuing to work on the project through junior independent work (MAE 339, fall 2015)
- Confirmed my inclination to pursue a career in academic research through graduate school
- Sparked an interest in turbulence that may turn into a primary research focus
**Personal Progress**

- Immersed myself in the rich scientific, philosophical, theological, and technological traditions of Germany
- Grew to appreciate German culture as manifested both in research and in everyday life
- Got to practice my German and meet some local students at a Wednesday night Bible study
- *Vielen Dank* to IIP for such a wonderful summer!