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**Thesis committee members:**

Prof. Dr. x (chairman)	UT, Enschede
Prof. Dr. y (promotor)	UT, Enschede
Prof. Dr. z (copromotor)	UT, Enschede
Prof. Dr. x	CEA, Paris
Prof. Dr. y	TUE, Eindhoven
Prof. Dr. z	MPI, Göttingen



Enabling new technology

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TITLE ENGLISH

DISSERTATION

to obtain  
the degree of doctor at the University of Twente,  
on the authority of the rector magnificus,  
Prof. Dr. H. Brinksma,  
on account of the decision of the graduation committee,  
to be publicly defended  
on Friday the 19th of September 2014 at 16:45

by

full name written out here  
Born on the day of birth e.g. 1st of January 1901  
in place of birth e.g. Amsterdam, The Netherlands

This dissertation has been approved by the promotor:

Prof. Dr. X

and the copromotor:

Assoc. Prof. Dr. Y

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# Introduction

Turbulence is omnipresent. It's in our blood, in our respiratory system, in our tea and coffee, in the hot air that rises above us, in the wake behind us when we walk, in the air in a room, around our cars and planes, in the wind above our farmlands, in the water of all the seas and oceans, in our sun, and in all the other stars.

For macroscopic flows of water and air the Reynolds number, the ratio of inertial to viscous forces and describing the amount of turbulence, is generally much larger than unity. This means practically that all the common flows around us are turbulent. The difficulty in describing turbulence resides in the fact that turbulent flows are generally irregular, chaotic, and therefore very hard to predict. Think of the weather; we can only predict a few days ahead—at best. In addition, turbulent flows have characteristics across many length- and time scales, so describing them is non-trivial. Although the equations describing them are well known, it has puzzled scientists for centuries and we have not yet 'solved' turbulence.

## Taylor Couette

The Taylor-Couette apparatus is one of the fundamental configurations to test theories in fluid dynamics....

## Open Questions

- Q1
- Q2
- Q3
- Q4

## A guide through the thesis

Up to now, for the high Reynolds numbers ( $> 10^4$ ), the focus...



# Chapter 1

## Ultimate turbulent Taylor-Couette flow<sup>1</sup>

main text here... [1]

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<sup>1</sup>Published as: **Sander G. Huisman**, Dennis P.M. van Gils, Siegfried Grossman, Chao Sun, and Detlef Lohse, *Ultimate Turbulent Taylor-Couette Flow*, Phys. Rev. Let. **108**, 024501 (2012). Experiments, analysis and writing are done by Huisman, supervision by Sun, and Lohse. Proofread by everyone.

## 1.1 Introduction

The Taylor-Couette (TC) system is one of the fundamental geometries...

$$\text{Re}_w \propto \text{Ta}^{1/2} \quad (1.1)$$

## 1.2 Experiment

The apparatus used for the experiments has an inner cylinder...

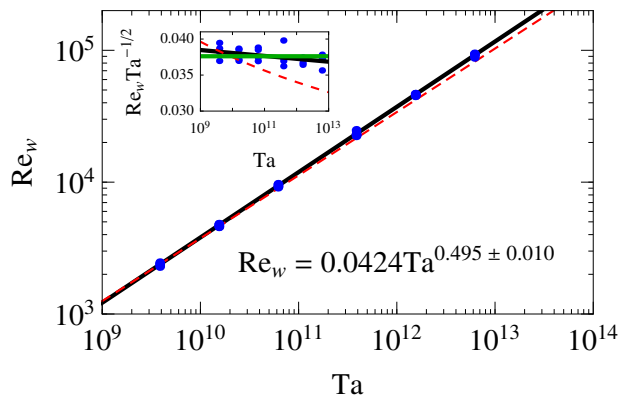


Figure 1.1: a nice image

## 1.3 Analysis and Results

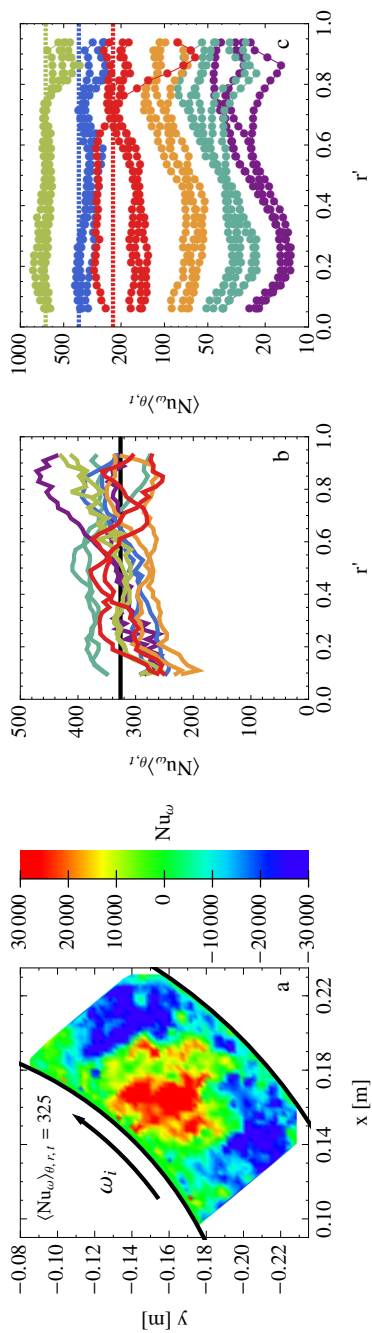


Figure 1.2: just to show you how a vertical page is done

## 1.4 Conclusion

In conclusion....

# Conclusions

In this thesis high Reynolds number Taylor-Couette flow has been examined...



# References

- [1] S. G. Huisman, D. P. M. van Gils, S. Grossmann, C. Sun, and D. Lohse, “Ultimate turbulent Taylor-Couette flow”, *Phys. Rev. Lett.* **108**, 024501 (2012).





# Summary

The ubiquity of turbulent flows in nature and technology...



# Summary (Frisian)

Turbulinte streamings binne oeral fertsjintwurdige yn 'e natoer en technyk...



# Summary (Dutch)

Turbulente stromingen zijn alomvertegenwoordigd in de natuur en techniek...



# Acknowledgements

acknowledgements here





# Bio

Sander Gerard Huisman was born in...



# Scientific output

## Publications

- **2014:** *Multiple states in highly turbulent Taylor-Couette flow*  
**Sander G. Huisman**, Roeland C.A. van der Veen, Chao Sun, Detlef Lohse  
Nat. Commun. 5, 3820
- **2012:** *Ultimate turbulent Taylor-Couette Flow*  
**Sander G. Huisman**, Dennis P.M. van Gils, Siegfried Grossmann, Chao Sun, Detlef Lohse  
Phys. Rev. Lett., **108**, 024501
- **2011:** *Torque scaling in turbulent Taylor-Couette flow with co- and counter-rotating cylinders*  
Dennis P.M. van Gils, **Sander G. Huisman**, Gert-Wim H. Bruggert, Chao Sun, Detlef Lohse  
Phys. Rev. Lett., **106**, 024502

