Analysis of perpendicular mean flows and fluctuations using Doppler reflectometry in the W7-X stellarator

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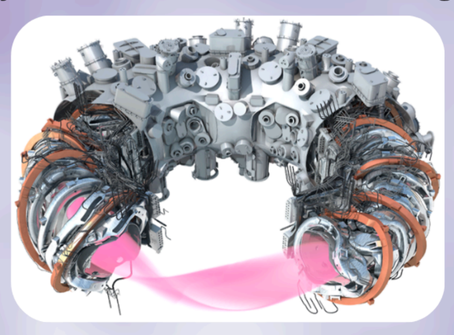
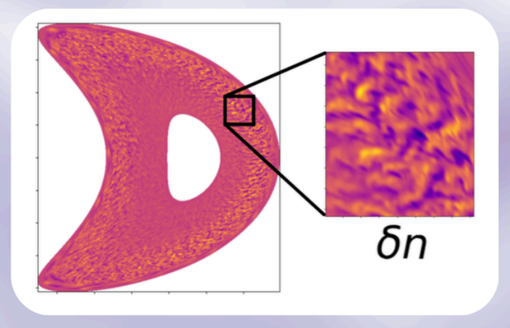
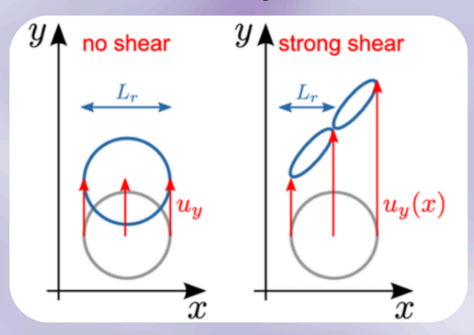
Introduction

- Turbulent transport, the dissipation of energy through the propagation of fluctuations, remains the greatest source of energy losses in a fusion plasma, thus compromising the viability of a fusion device.
- It's believed that sheared profiles in the plasma velocity can help in supressing turbulence, by stretching and breaking apart turbulent structures. With this in mind, the application of Doppler reflectometry to plasmas in the Wendelstein 7-X (W7-X) stellarator of the Max Planck Institute for Plasma Physics is studied, since this diagnostic provides information on both the plasma's velocity and the size of its density fluctuations.

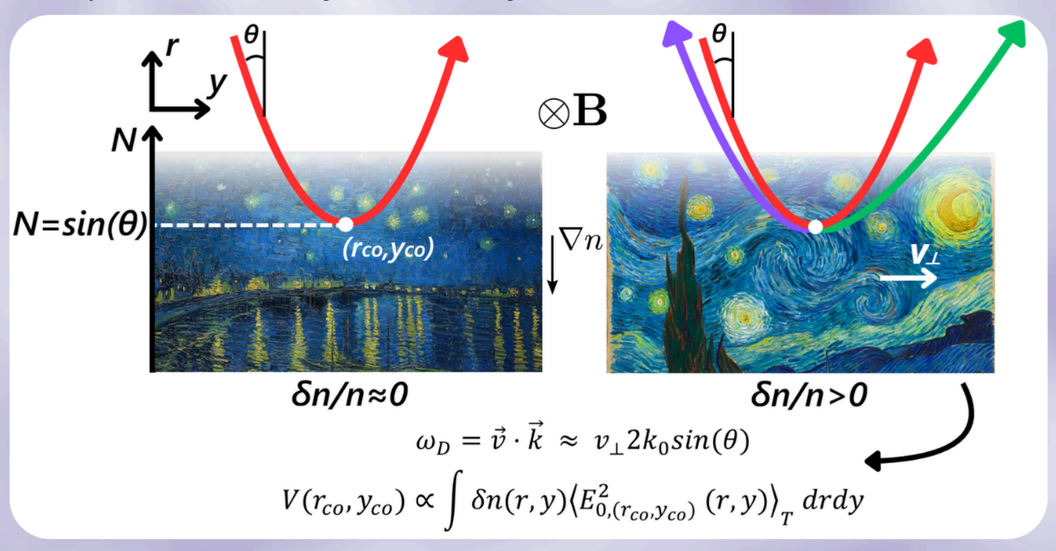






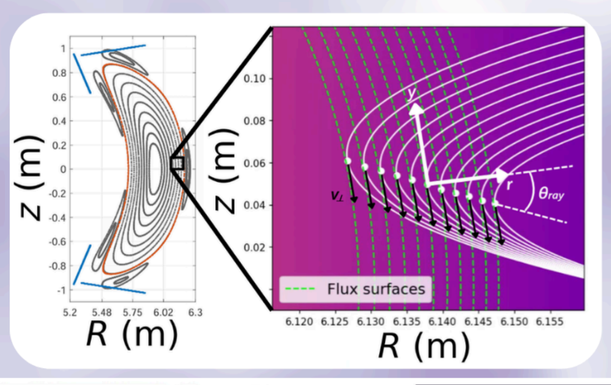
Doppler reflectometry

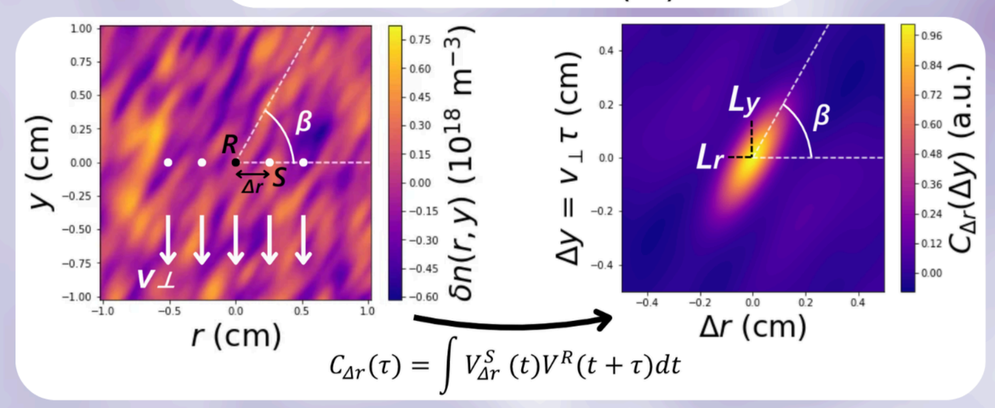
- A fluctuation-free fusion plasma, illustrated below by *Starry Night Over the Rhône* [4], reflects electromagnetic waves in a single direction.
- A turbulent plasma, illustrated below by *The Starry Night* [5], reflects waves in multiple directions, similar to when light hits a rough surface, and their backscattered (purple) component carries information about the plasma's velocity and density fluctuations.



Correlation measurements

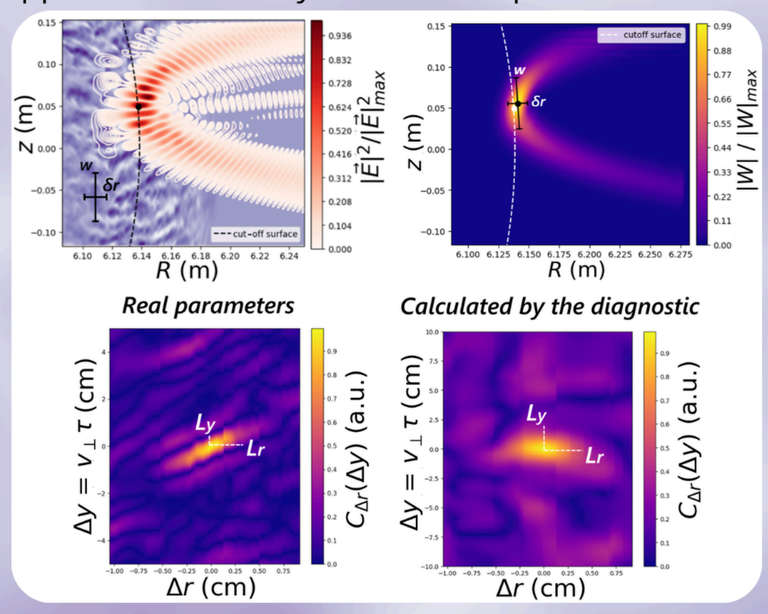
- It's possible to convert a complex turbulence profile *δn(r,y)* into a single, easy to analyse, structure with features that closely follow those of the probed turbulent structures.





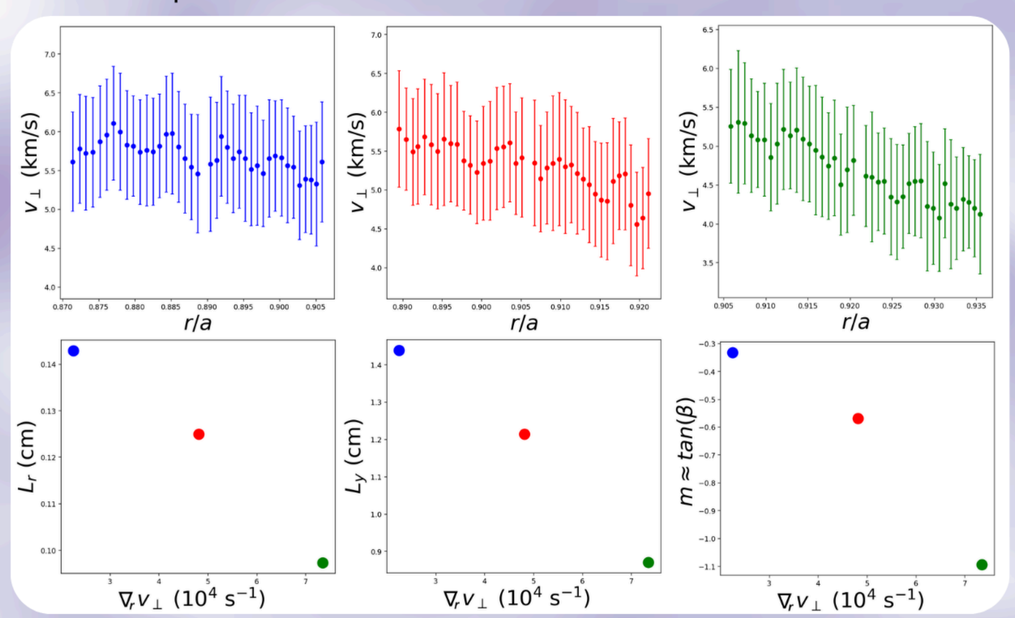
Full-wave simulations

- To study how the diagnostic affects the measurements of the true turbulence parameters, 2D full-wave simulations are performed to apply Doppler reflectometry to a realistic plasma of W7-X.



Experimental results and conclusions

- Applying Doppler reflectometry to investigate the turbulence parameters leads to a slight overestimation of *Lr*, with *Ly* and *β* being the less accurately predicted parameters, since *δr>Lr* and *w>>Ly*.
- The diagnostic can be used to impose upper limits on *Lr* and *Ly* in the probed region and to investigate differences in the values of the calculated parameters between different scenarios in W7-X.



- The correlation lengths and the tilt angle are observed to decrease with the increase in the velocity profile's shear.

References

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Acknowledgements

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