Poloidal wave number spectra and ρ_s scaling in TJ-K

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Introduction

In the low-temperature plasma (dimensionally similar to the edge of fusion plasma) of the torsatron TJ-K, the perpendicular dynamic of turbulence has been investigated with the objective to study the poloidal wave number spectra and the size scaling of the turbulent structure with $\rho_s=(T_eM_i)^{1/2}/eB$. Previous investigations, which used poloidal and 2D probe arrays with 64 tips, have been extended to smaller scales and to a larger ρ_s variation. This has been achieved by remodelling the probe array and by increasing the magnetic field from B=0.1 up to 0.3 T. Discharges are compared, where ρ_s was changed through both M_i and B. ρ_s was varied from 0.1 cm to 3 cm. For all discharges, the wave number spectra show a power law with spectral indices from -2 to -3. The cross-phase was found to be around zero at all scales. Finally, poloidally resolved turbulence was measured and differentiated between low-field and high-field side .

The Torsatron TJ-K

Parameters

Major radius 0.6

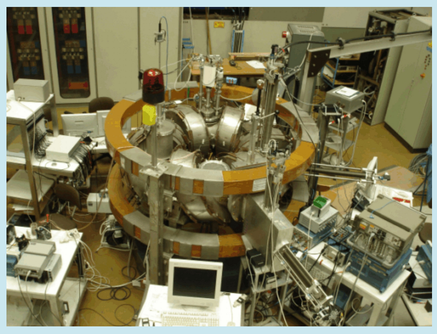
Minor radius 0.1

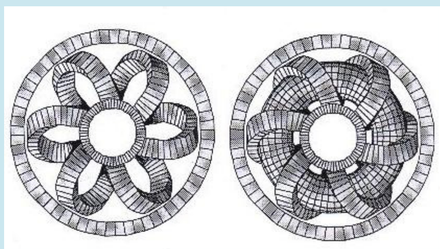
Iota = 0.3

$B < 0.3$ T

$n_e < 6\times10^{17}$ m^{-3}

$T_e < 20$ eV



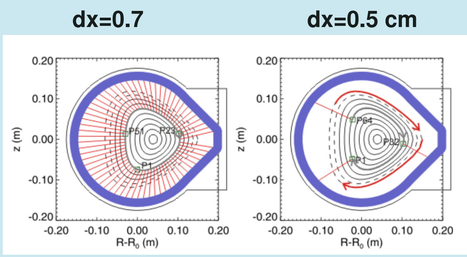


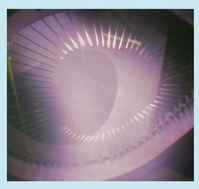
Diagnostics

Probe arrays

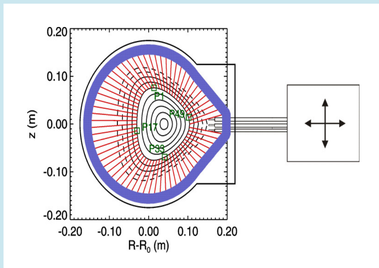
poloidal resolution of

dx=0.7 dx=0.5 cm





2D-probe

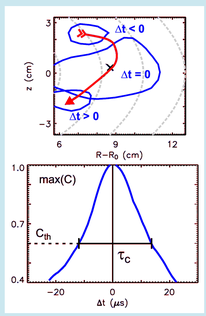


Measuring of the turbulent transport and the wave spectrum by using the probe array

$$\Gamma = \left\langle \tilde{E}_\theta \tilde{n} \right\rangle_{F,t}$$

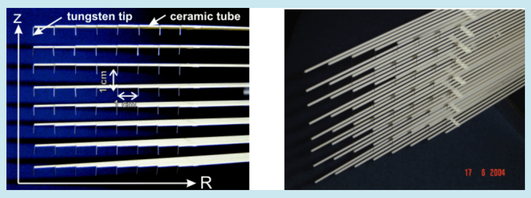
Detection of the turbulent structures by using the cross-correlation function

$$C_{i,j}(\Delta t) = \int \frac{\tilde{n}_{ref}(t)}{\sigma_{ref}} \frac{\tilde{n}_{i,j}(t+\Delta t)}{\sigma_{i,j}} dt$$

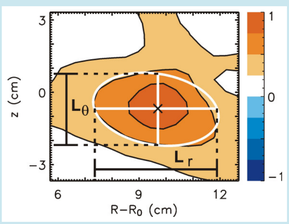


$$T \sim \frac{a}{c_s} = a\sqrt{\frac{T_e}{m_i}}$$

Matrix



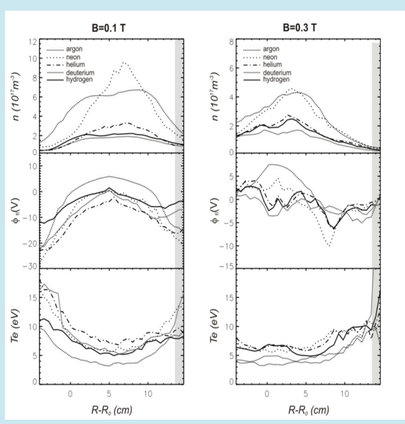
Scaling of characteristic lengths and times



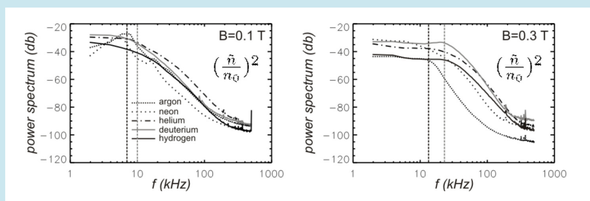
$$L \sim \rho_s = \frac{\sqrt{m_i T_e}}{eB}$$

Equilibrium Profiles and Basic Properties of The Fluctuations

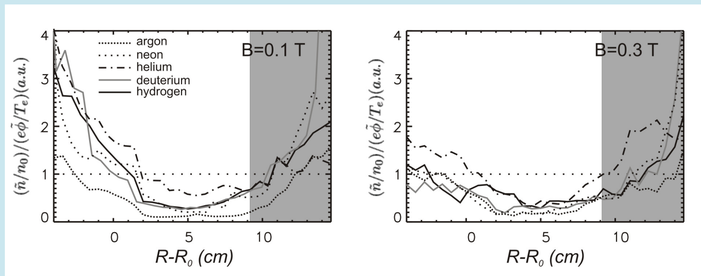
equilibrium Profiles



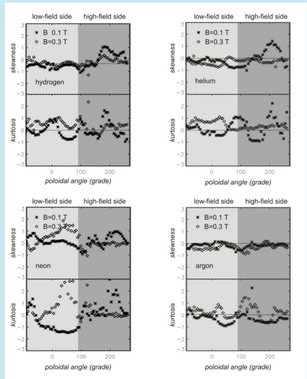
power spectra of the normalised density fluctuations



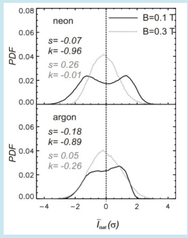
normalised fluctuations for all discharges



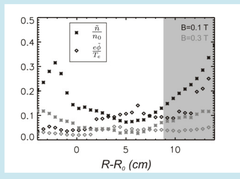
Skewness and kurtosis



PDF



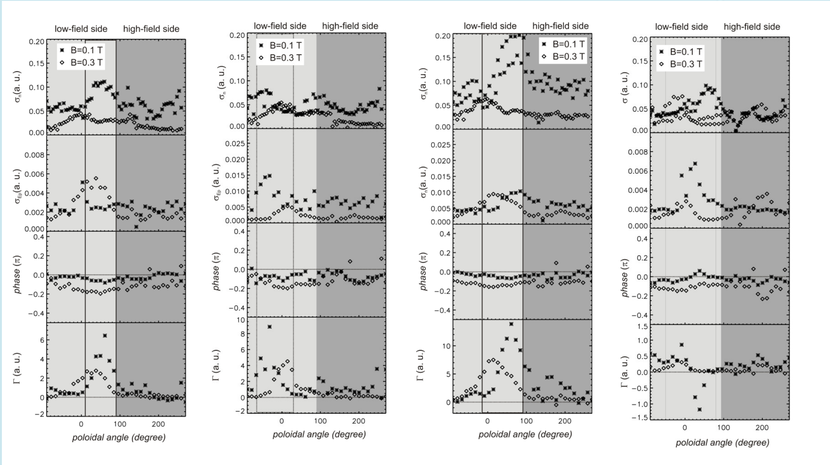
fluctuation level



- The fluctuation degree is decreased at B=0.3 T.
- in the region of the density gradient, the ratio of the normalised fluctuations is found to be $\langle \tilde{n}/n_0 \rangle / \langle e\tilde{\phi}_p / T_e \rangle \geq 1$

Turbulent Transport

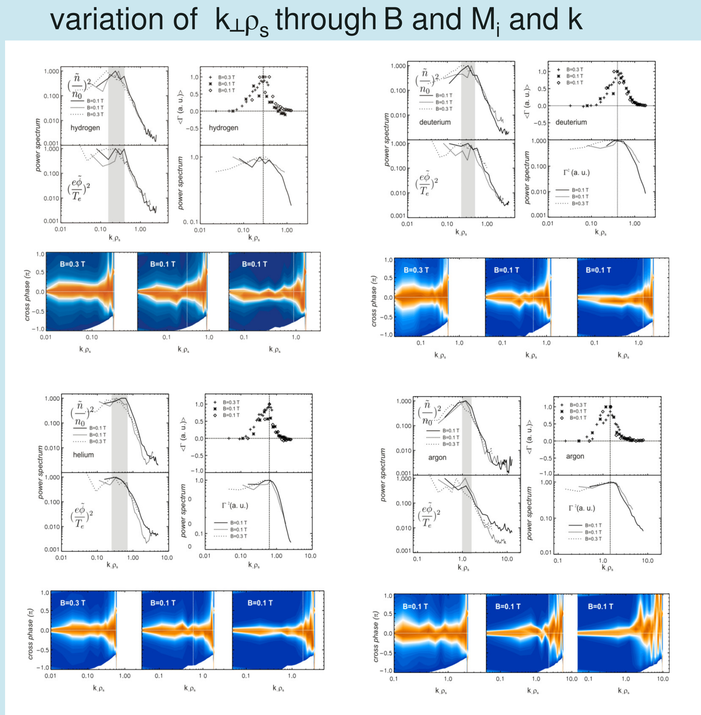
hydrogen deuterium helium argon

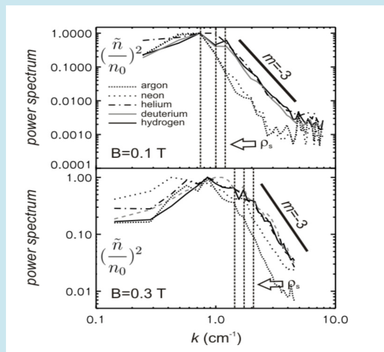


- Due to the fluctuation level in the density and the poloidal electric field, the turbulent transport is the largest on the LFS.
- The cross-phase is smaller than 0.3 π.
- The turbulent transport is larger at B=0.1 T.

Wave Number Spectra

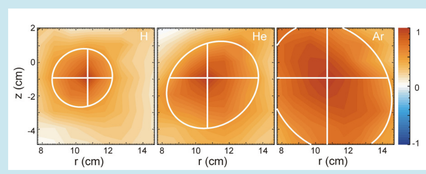
variation of $k_\perp\rho_s$ through B and M_i and k





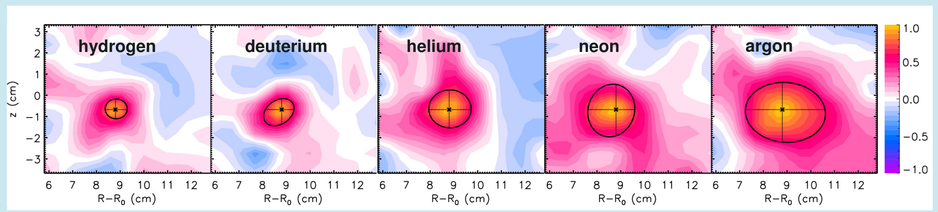
- The wave number spectra are Kolmogorov- like.
- Spectral index of -3
- The maximum of the wave spectra is in-between $1.5>k_\perp\rho_s>0.3$ in TJ-K.
- The cross-phase is distributed around zero at all scales.
- The maximum transport is observed at intermediate scales at both B=0.1 and B=0.3 T
- At small scales $k_\perp\rho_s>1$, an inward transport is found for the helium discharges .
- ρ_S scaling on all scales, spectra shift by factor of 3.

ρ_S Scaling



B=0.1 T

0.4 cm → ρ_S → 3 cm

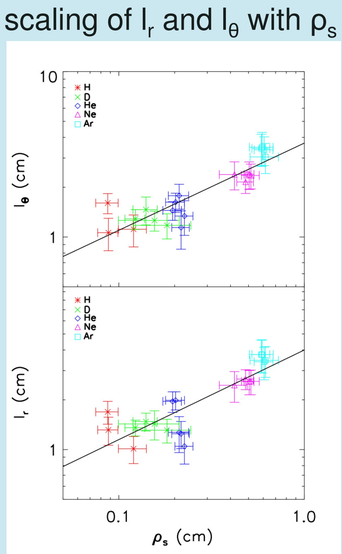


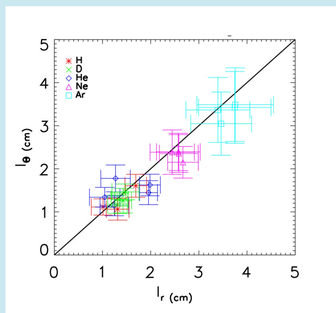
B=0.3 T

0.1 cm → ρ_S → 1 cm

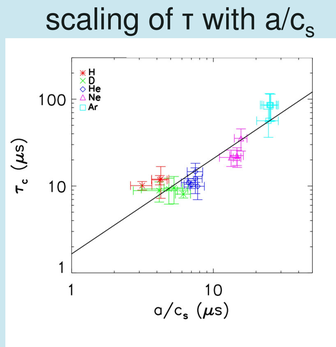
correlation lengths

scaling of l_r and l_θ with ρ_s





scaling of τ with a/c_s



- Limitation due to spatial resolution for hydrogen and deuterium
- scaling is less than linear:
  $l_r=\rho_s^{0.54\pm0.081}$, $l_\theta=\rho_s^{0.53\pm0.06}$
  $\tau_c=(a/c_s)^{1.1\pm0.11}$

Summary

- Turbulent transport was studied on the low- and high field side
- Turbulence consists of drift-waves at all scales
- The wave number spectra were measured for a wide range of scales $0<k_\perp\rho_s<15$
- Scaling appears less than linear

Acknowledgement

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