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Simulation of turbulent plasma heat flux to the DEMO first wall

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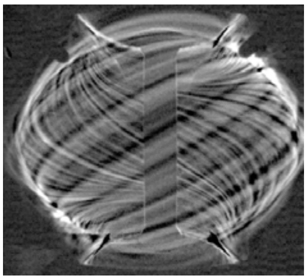
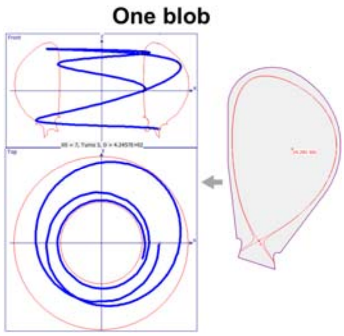
ABSTRACT/CONCLUSIONS

- Assessment of the first wall (FW) heat load in DEMO is one of the key design issues determining the reactor.
- The heat load is a challenge for the FW armor material because of operational temperature and sputtering
- FW heat load caused by the plasma turbulent heat flux associated with plasma blobs is described
- Nowadays for calculation of the wall heat flux the exponential decay assumption for the dependence of parallel heat flux on the radial coordinate in the midplane is widely used.
- This assumption gives rather rough approximation for the real flux dependence, however it is reliable and robust enough to give approximate evaluation of the heat flux distribution along the DEMO first wall
- New model, which simulates the turbulent heat flux through plasma dynamics inside each blob and the wall heating by this plasma at the blob faces is developed and implemented into the TOKES code.
- This model does not used the approximate exponential decay assumption
- First simulation has been performed for P_{sep} = 46 MW, T_e = 100 ev, $n_e = 10^{19}$ m^{-3} and $v_\perp$ = 400 m/s.

TURBULENT PLASMA TRANSPORT IN SOL BY BLOBS

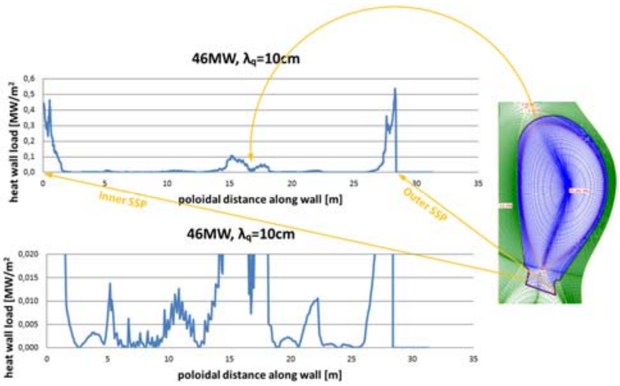


Blobs in MAST. Reprint from: Dudson B D et al 2008 Plasma Phys. Control. Fusion 50 124012

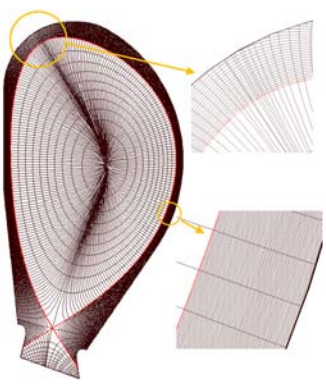


One blob in DEMO

TURBULENT PLASMA HEAT FLUX IN EXPONENTIAL DECAY APPROXIMATION



TOKES MODEL FOR PLASMA TRANSPORT IN BLOBS



TOKES calculation grid for blobs simulation in SOL and heat flux deposition onto the first wall

THE MODEL

- Blob tube is always stretched along magnetic field
- The blob tube moves ⊥ to magnetic field with prescribed velocity
- Heat deposited onto the wall at the blob faces
- Fluid dynamics for the plasma inside the blob
- Electron and ion thermoconductivity
- Plasma convection along the tube
- Initial state is constant T_e and n_e along the blob close to the separatrix

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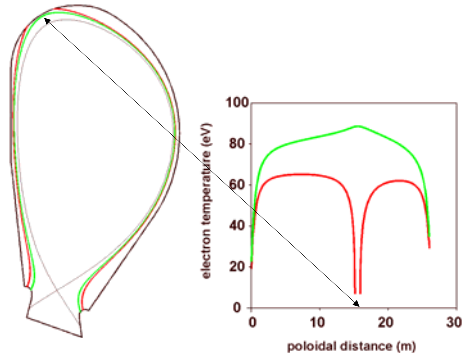
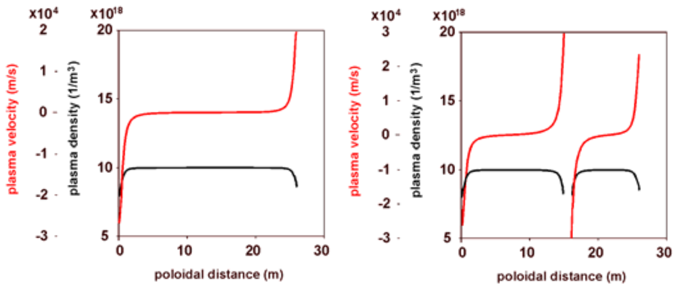
TOKES SIMULATION RESULTS

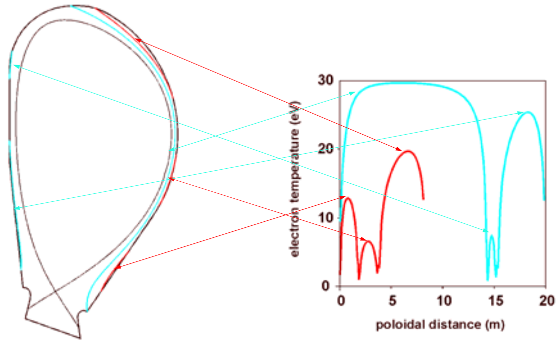
- Initially the blob is spanned from outer divertor target to the inner one with constant T_e and n_e and with zero parallel velocity.
- At some time moment the blob touches upper wall by its central part, where T_e and n_e are maximal.
- This explains local heat flux maximum at this wall position
- Position of the heat flux maximum determined by the DEMO magnetic configuration



- Position of the enhanced heat flux at upper wall and corresponding temperature drop inside the blob



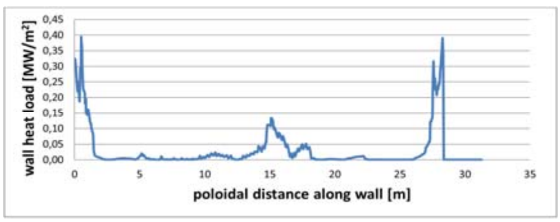
- Blob plasma flows along the magnetic field towards the points of the wall touching
- The flow patter changes when new touching point arises



- Further partition of the blob:

FIRST TOKES SIMULATION RESULT

- Total plasma heat flux through the separatrix is 46 MW, T_e = 100 ev, $n_e = 10^{19}$ m^{-3} and $v_\perp$ = 400 m/s.



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