



HAL
open science

Simulations of impurity transport with TERESA and GYSELA codes

Maxime Lesur, Kyungtak Lim, Lo-Cascio G., Garbet X., Sarazin Y., Etienne Gravier, Réveillé T., Chabha Djerroud, Idouakass M., Guillevic A., et al.

► **To cite this version:**

Maxime Lesur, Kyungtak Lim, Lo-Cascio G., Garbet X., Sarazin Y., et al.. Simulations of impurity transport with TERESA and GYSELA codes. US-EU joint Transport Taskforce Workshop, Apr 2022, Santa Rosa, United States. 2022. hal-04595305

HAL Id: hal-04595305

<https://hal.univ-lorraine.fr/hal-04595305>

Submitted on 3 Jun 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Simulations of impurity transport with TERESA and GYSELA codes

M. Lesur¹, K. Lim², G. Lo-Cascio¹, X. Garbet³, Y. Sarazin³, E. Gravier¹, T. Réveillé¹,
 C. Djerroud¹, M. Iduoukass⁴, A. Guillevic¹, K. Obrejan³, J. Moritz¹, V. Grandgirard³
¹IJL, CNRS/U.Lorraine, Nancy, France ; ²Swiss Plasma Center, Lausanne, Switzerland ;
³CEA, IRFM, St-Paul-lez-Durance, France ; ⁴NIFS, NINS, Toki, Japan



Context: gyrokinetic simulations of impurity transport in the core of tokamaks

Objective: Impacts of impurity concentration, charge, mass, gradients & tor. rotation

Method: • 4D bounce-averaged gyrokinetic simulations (TERESA)
 • 5D gyrokinetic simulations with realistic collisions (GYSELA)

Part 1: Impact of concentration

Scan of tungsten concentration in TEM turbulence with TERESA

- TEM growth rate and turbulence intensity ↓ with ↑ tungsten concentration C, linearly for concentrations below 5.10^{-4} ($C Z^2 < 0.8$)
- Consistent with [Dominguez NF'89] [Du NF'14]
- For turbulent transport of W^{40+} , passive treatment valid for $C < 2.10^{-4}$ ($C Z^2 < 0.3$)

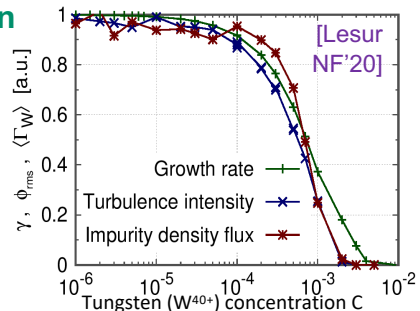


Fig.1. Transition between passive and active W

Part 2: Diffusion, thermo-diffusion, and curvature pinch

Three terms of TIM and TEM turbulent transport can be isolated in TERESA, and parametric dependencies investigated separately

$$\Gamma_Z = -D_Z [\nabla n_Z + C_T \nabla T_Z + C_P \nabla q]$$

Increases (decreases) with increasing Z for TEM (TIM)

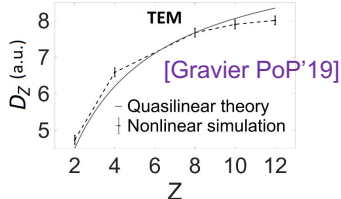


Fig.2. Impurity diffusion against charge number Z

Thermodiffusion:
 $C_T \downarrow$ as $Z \uparrow$ TEM → inwards
 TIM → outwards

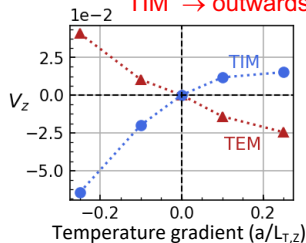


Fig.3. Thermodiffusion velocity V_Z versus impurity temperature gradient

Curvature pinch: inward except for strong reversed magnetic shear

Consistent with [Futani PRL'10]

[Lim PPCF'20]

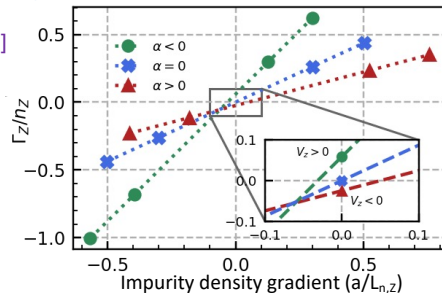


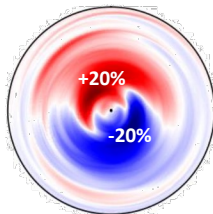
Fig.4. Impurity density flux for $\nabla T_z = 0$, for different signs of magnetic shear α

Part 3: impurity transport in ITG turbulence with realistic collisions

Heat source-driven GYSELA simulations with both neoclassical and turbulent transport

[Estève NF'18] [Donnel NF'19]

- Light Z → turbulent transp. → hollow density profile
- High Z → neoclass. transp. → peaked density profile
- Turbulence generates 20% up-down asymmetry for tungsten, impacting neoclassical transport



[Lim NF'21] Fig.5. Poloidal distribution of tungsten

- Toroidal rotation increases in-out asymmetry and central tungsten accumulation.
- Consistent with [Angioni PPCF'14]

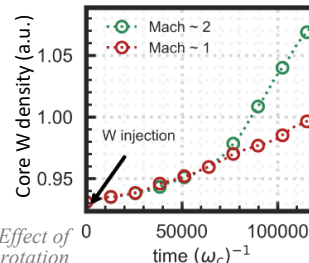


Fig.6. Effect of toroidal rotation