

Collaboration with U.S. on Theory and Simulation*



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General framework

- Center for Nonlinear Plasma Scinece (CNPS):
 - <https://www.afs.enea.it/zonca/CNPS/>
 - Established in 2020 as "**Virtual Center**" based on two hubs, one located at the ENEA Frascati Research Center and another at the University of Science and Technology of China, Hefei, to **promote a joint research and collaboration network**.

→ Presentation by G.Vlad
& M.V. Falessi

- International collaboration network

- University of California at Irvine (Dept. Physics & Astronomy -L. Chen, Z. Lin)
- Auburn University (Physics Dept. - Y. Lin)
- Dartmouth College (R. Onofrio, L. Viola)
- Princeton PPL (R.B. White, F. Poli, M. Podestà)

- Department of Physics and Astronomy:
 - Continuing long lasting collaboration with L. Chen (since 1994): recent research topics
 - **Transport theory of phase space zonal structures:** in collaboration with IFTS (LC, ZQ, MVF, FZ)
 - **Innovative formulation of Nonlinear Gyrokinetics:** E&B formulation based on moment approach with applications to long time scale simulations of stability and transport (CNPS-DTT seminars)
 - Participation in the ISEP (Z. Lin) SciDAC project on **Integrated Simulation of Energetic Particles in Burning Plasmas** (since 2017)

□ Physics Department:

- Space Physics and Fusion Physics (Yu Lin, also @ USTC – Connection with hub of CNPS@USTC)
- Development of advanced nonlinear kinetic theory:
 - **GeFi code**: Y. Lin, X.Y. Wang, Z. Lin and L. Chen: moment approach to field equations with **GK closure for electrons** and **full kinetic description for ions** (PPCF 05)
 - Developed in **3D slab geometry** for **space applications**
 - Modified to **E&B formulation** and **cylindrical geometry**
 - To be extended to **3D tokamak geometry**
- Topic of PhD Thesis @ «Roma Tre» University → **Livio De Fabrizio** «Nonlinear kinetic theory and simulation of toroidal fusion plasmas»

□ PhD sponsored by ENEA@CNPS: → PhD Thesis:
Livio De Fabrizio

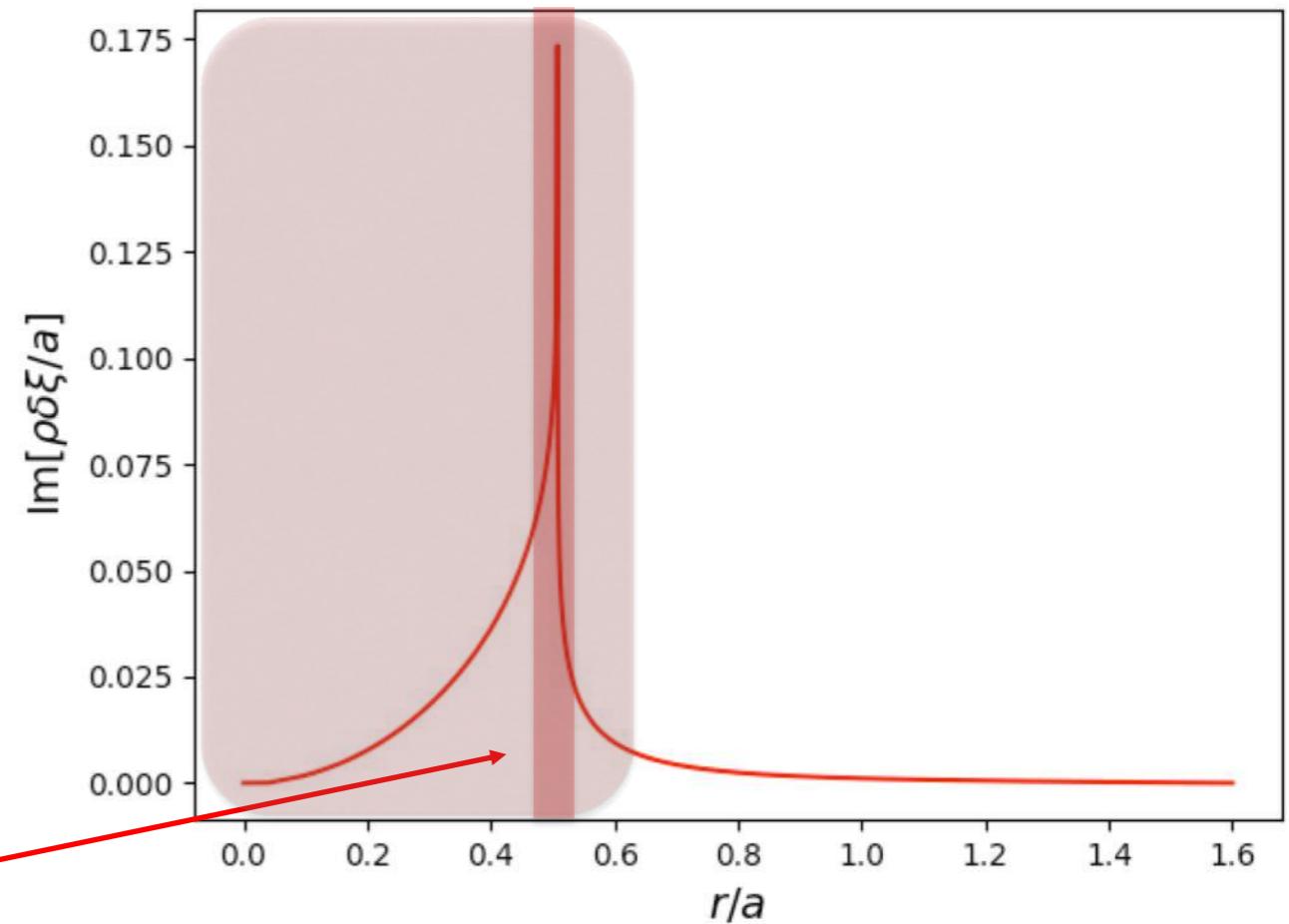
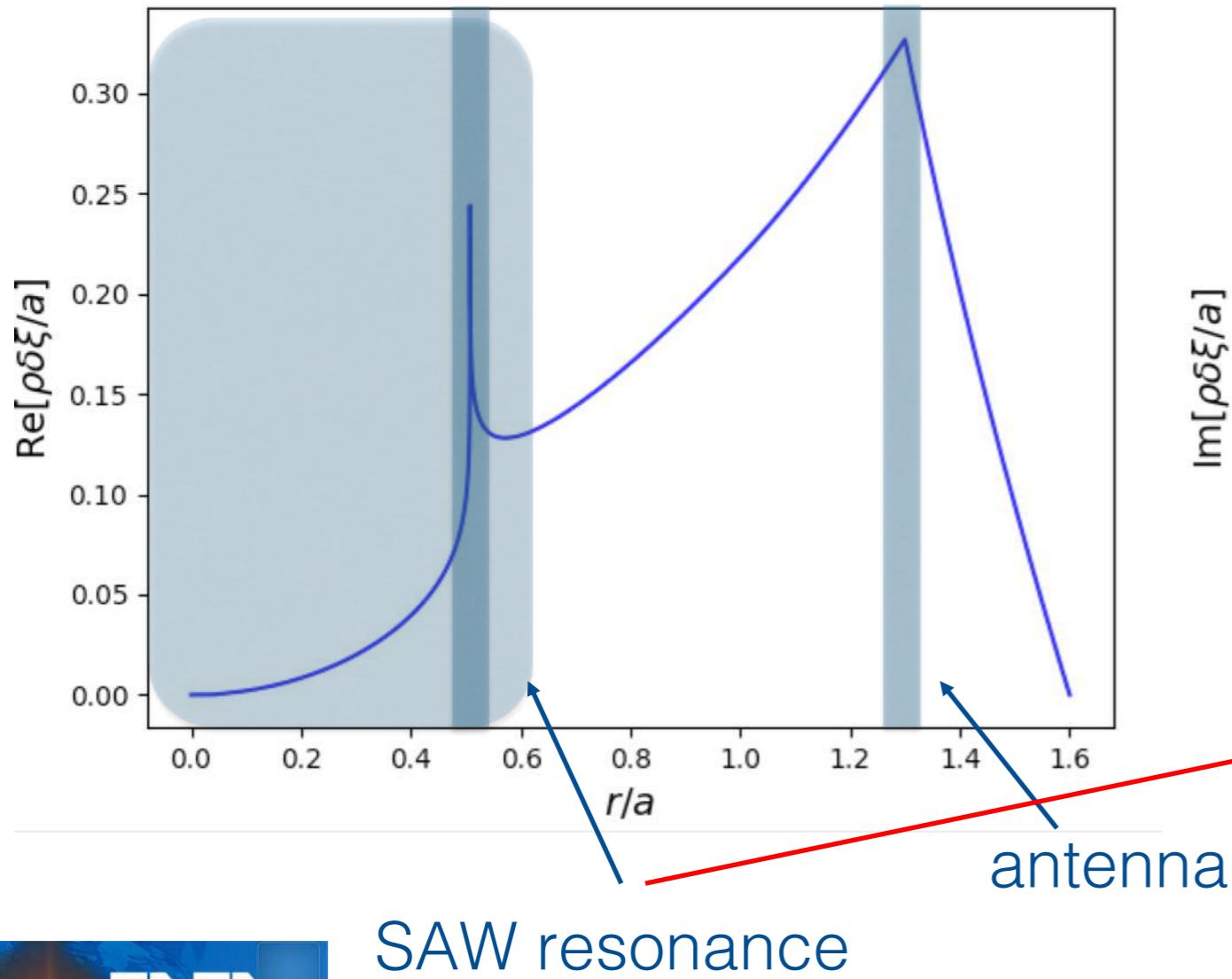
- Aim: to develop GeFi code in toroidal geometry
- Shift of topic (not aim) due to pandemic:
 - Focus on **generation of convective cells by KAW** in cylindrical plasma → Generation of **d.c. parallel electric field** breaking the standard **Dawson-Tajima paradigm of plasma acceleration**
 - Verification of theory against GeFi simulation results in cylindrical geometry
 - Use both standard (potential) formulation of GeFi and **E&B formulation**
 - **Testbed for further GeFi extension to 3D geometry**

«Roma Tre» University II

□ Preliminary results:

→ PhD Thesis:
Livio De Fabrizio

- Kinetic Alfvén wave absorption in plasma cylinder
- Strong damping: classical case of KAW heating



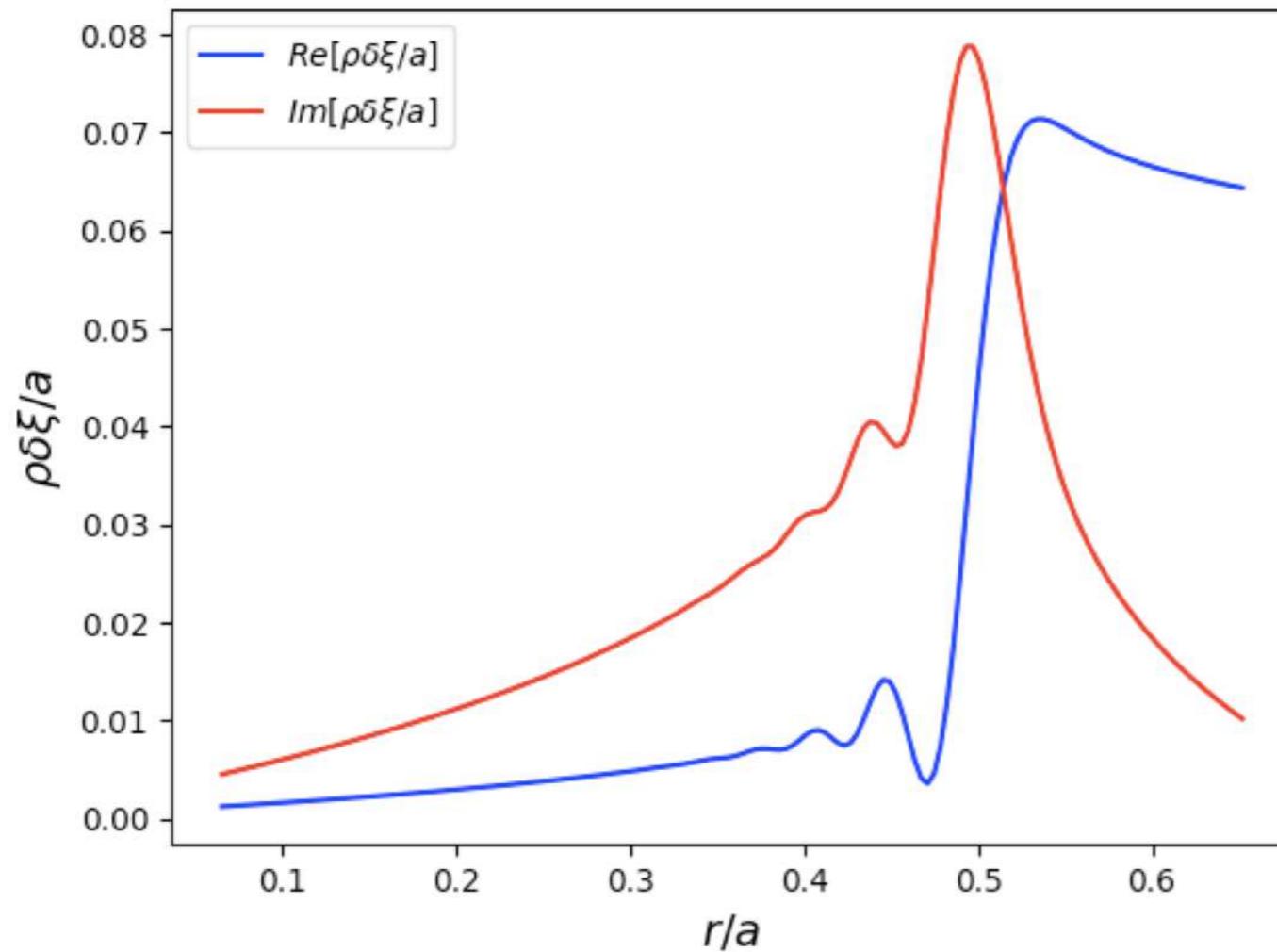
✓ Shear Alfvén wave resonant absorption (Chen, Hasegawa 1974)

□ Preliminary results:

→ PhD Thesis:
Livio De Fabrizio

- Kinetic Alfvén wave absorption in plasma cylinder

$$\alpha_{\text{GK}} = (-0.649891262747921, -0.000905658887802756)$$



GK yields slightly larger absorption

$$\alpha_{\text{MHD}} = (-0.650467168434622, -0.0007458260374130444)$$

□ Preliminary results:

→ PhD Thesis:
Livio De Fabrizio

- Kinetic Alfvén wave absorption in plasma cylinder
- Weak damping: KAW cavity modes and generation of convective cells/parallel electric field

- Nonlinear analytical study → in progress
- Verification of theory against GeFi simulation results in cylindrical geometry → next step

□ Department of Physics and Astronomy:

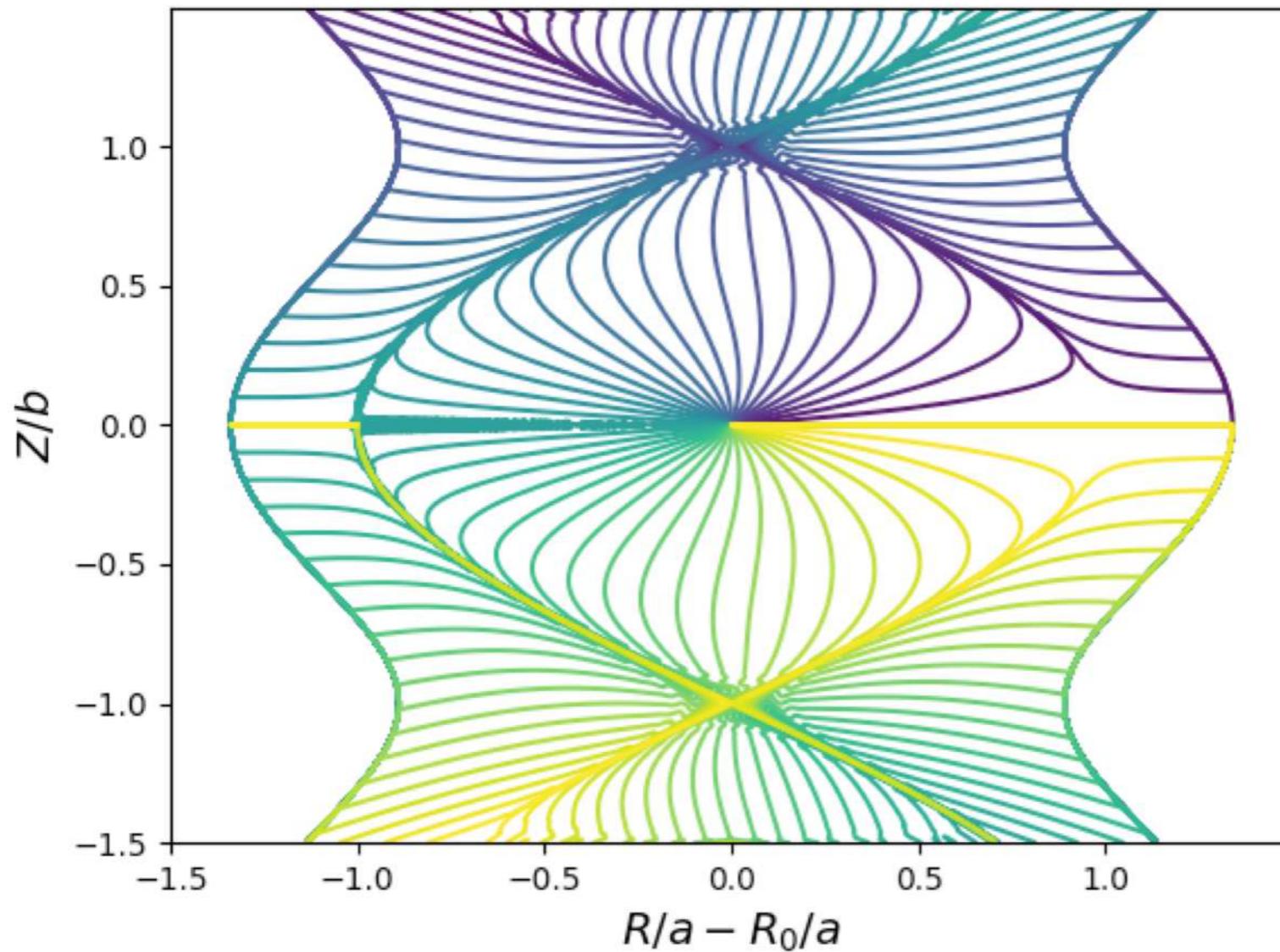
- Physics of plasmas and fluids (Barrett N. Rogers, Yi-Shin Liu, John Lion, Tack Chu Li, Xiaocan Li, RO, LV)
- Research topics of common interest:
 - **Physics of burning plasmas:** Roberto Onofrio, with application to SPARC @ MIT
 - **Techniques from quantum information processing and quantum control:** Lorenza Viola, with applications to enhanced and real-time feedback control of plasma scenarios
- Possible collaboration Dartmouth-ENEA-MIT on DTT/SPARC

➤ Breaking myths in plasma physics

→ Application to test particle transport

→ ORBIT (R.B. White)

→ Master Thesis:
Leonardo Corsaro UCL



Model equilibrium
with double X-point

Boozer isolines

➤ Energetic particle transport: F. Poli, M. Podestà (TRANSP)

Questions/Comments

- Questions/comments are welcome

