Fédération Sciences Plasmas Fusion

Année universitaire / Academic year 2020-2021

PROPOSITION DE STAGE / INTERNSHIP PROPOSAL

Institution : Aix-Marseilles university & CNRS
Laboratory : umr 7345 physique des interactions ioniques et moléculaires
Location : service 362, campus Saint-Jérôme, Marseilles
Supervisor : Pr Y. Elskens, équipe turbulence plasma

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Internship conditions (salary, travel, lodging, food,…) : legal internship support

Title : **Wave–particle interaction in a traveling wave tube**

The interaction of charged particles with one or several waves is a fundamental process underlying many phenomena in various areas of physics, including plasmas, electrodynamics, accelerator physics... Challenging aspects of this process include Landau damping (a dissipationless relaxation process in a hamiltonian system), radiation reaction,...

Our device is a 4-m long (unique in the world) traveling-wave-tube. Traveling wave tubes are used as telecommunication amplifiers for space probes and commercial satellites. Their operating principle (the momentum exchange between an electron beam and an electromagnetic wave propagating in a waveguide with a phase velocity close to resonance) rests on simple fundamental physics : the (nonlinear) pendulum, the (forced) harmonic oscillator and conservation laws. Our device enabled us to observe directly in the lab several fundamental processes of nonlinear hamiltonian dynamics.

The internship may investigate various issues :

- characterizing the waveguide-antenna couplings along the propagation structure ;
- replacing the steady electron beam emitted at the cathode with a pulsed bunch of electrons : this makes the device even closer to a few degrees-of-freedom system ; in this regime, we can investigate the robustness of the amplification processes usually obtained in the steady-beam case ;
- coupling a wide spectrum of waves with a warm beam results in chaotic evolution of the electron velocities and irregular amplification : the simpler theories for this system predicts results wich are observed on average, but rest on hypotheses which the system actually violates ; assessing them experimentally is very desirable.

The internship will complement analytical and numerical investigations in the current Ph.D. thesis in collaboration with CNES and Thales.

F. Doveil, D.F. Escande & A. Macor, *Experimental observation of nonlinear synchronization due to a single wave*, **Phys. Rev. Lett. 94** (2005) 085003 (4 pp.).

A. Macor, F. Doveil and Y. Elskens, *Electron climbing a « devil's staircase » in wave-particle interaction*, **Phys. Rev. Lett. 95** (2005) 264102 (4 pp.).

M.C. de Sousa, F. Doveil, Y. Elskens and I.L. Caldas, *Wave-particle interactions in a long traveling-wave tube with upgraded helix*, **Phys. Plasmas 27** (2020) 093108 (11 pp.), hal : 02876141.

https://phys.org/news/2019-03-traveling-wave-tubes-unsung-heroes-space.html

PhDs : A. Macor (2007), A. Aïssi (2008), P. Bernardi (2011), S. Théveny (2016), D. Minenna (2019), Kh. Aliane (current).