ACTIVE-STERILE NEUTRINO OSCILLATIONS IN DENSE ENVIRONMENTS

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Proposta di Use Case per il WP 1 del CN-HPC del PNRR

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SCIENTIFIC CASE

Neutrino flavor conversion in dense environments (e.g. **early Universe, Supernovae**...)

- Theoretically interesting
- Phenomenological implications:
  - Primordial nucleosynthesis and light elements yields
  - Cosmological density of relic neutrinos, both active and sterile (neutrino masses, effective number of species)
  - Nucleosynthesis of heavy nuclei in stars
  - Explosion of massive stars

2+1 density matrix

$$\varrho(x,y) = \begin{pmatrix} \varrho_{ee} & \varrho_{e\mu} & \varrho_{es} \\ \varrho_{\mu e} & \varrho_{\mu\mu} & \varrho_{\mu s} \\ \varrho_{se} & \varrho_{s\mu} & \varrho_{ss} \end{pmatrix}$$

Equation of motion:

$$i\frac{d\varrho}{dx} = +\frac{x^2}{2m^2\,y\,\overline{H}}\left[\mathsf{M}^2, \varrho\right] + \frac{\sqrt{2}G_F\,m^2}{x^2\,\overline{H}}\left[\left(-\frac{8\,y\,m^2}{3\,x^2\,m_W^2}\mathsf{E}_\ell - \frac{8\,y\,m^2}{3\,x^2\,m_Z^2}\mathsf{E}_\nu + \mathsf{N}_\nu\right), \varrho\right] + \frac{x\,\widehat{C}[\varrho]}{m\,\overline{H}}$$

Vacuum oscillations

Matter effects
(e+ and e-)

Matter effects
(neutrino self
interactions)

Collisions

+ similar equation for the density matrix of antineutrinos
+ continuity equation

OBJECTIVE AND BENCHMARKS

We aim at being able to solve the equation of motion for ρ:

- Using ~10 corehrs
- With a 10^{-2} absolute precision on Neff
- Multimomentum
- Multiflavour
- Accounting for lepton asymmetries

... with the final objective of performing a scan in parameter space (asymmetries+mixing angles+masses).
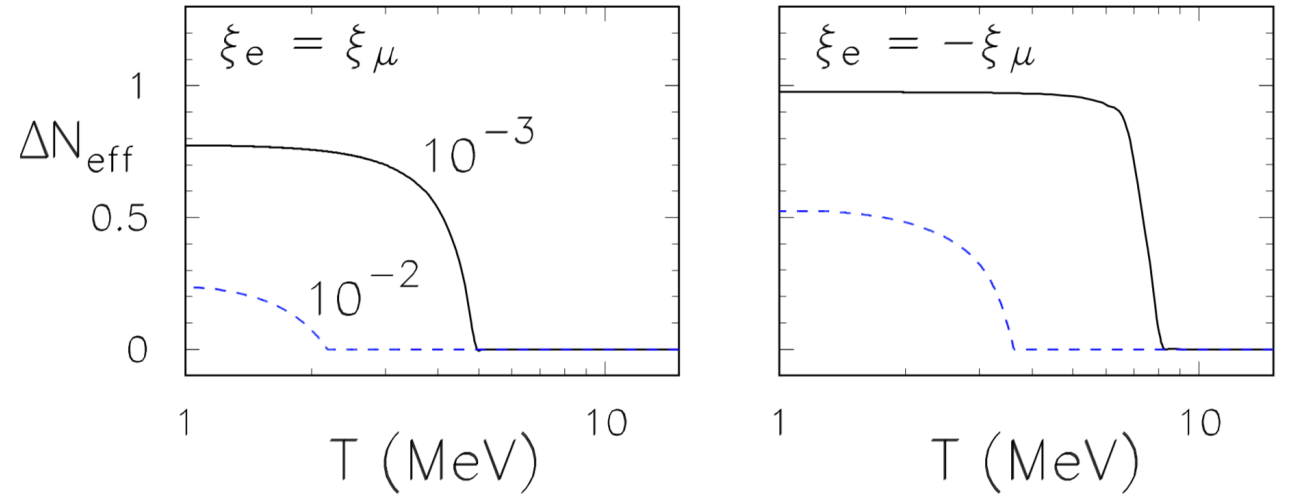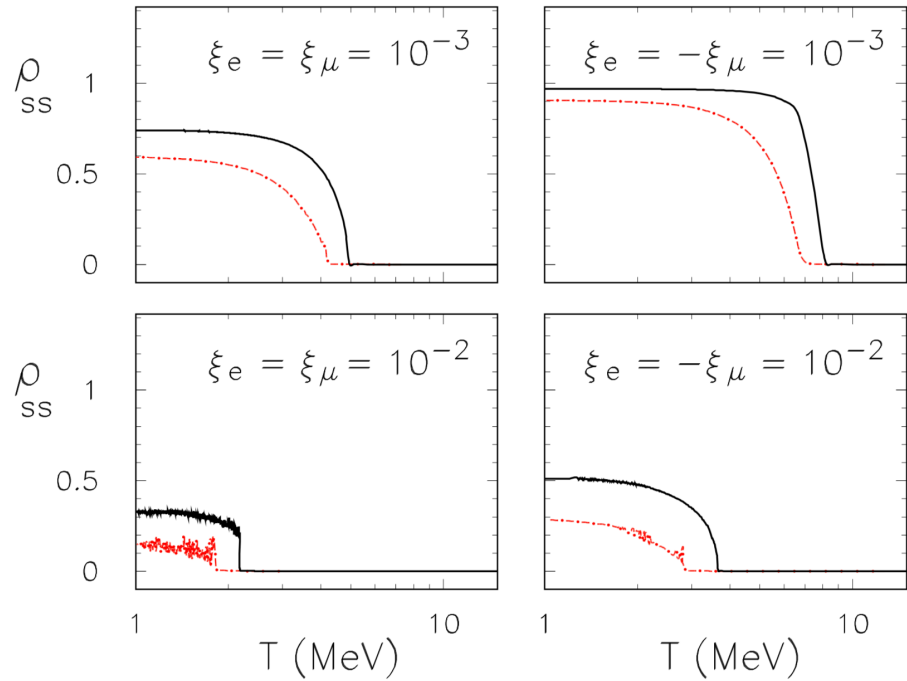
N. Saviano et al., PRD 2013

Possible strategies (not mutually exclusive...) to bring down the time requested to solve the EoM at fixed parameter values:

- Optimization of the solver
- Choice of the momentum discretization scheme
- Use emulators for the computation of collision terms

+ use emulators to solve the EoM when performing the MC ?

Personnel

- M. Lattanzi (INFN Ferrara, staff)
- N. Saviano (INFN Napoli, staff)
- + assegnista/RTD to be recruited with open call at SSM (?)

Requests

- Access to a small cluster for development purposes (200 kch)
- Access to an HPC cluster for test and production purposes (1Mch)

Possible extensions

Neutrino oscillations in SN

Axion-photon conversion in cosmological/astrophysical magnetic fields