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Geometrically reduced kinetic simulations of fusion plasmas.

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Strongly magnetized fusion plasmas represent complex multi-scaled systems in space and time.

Therefore, reduced models are mandatory for accessing fundamental physical mechanisms in a different regimes (e.g., turbulent, collisional) and geometry configurations. Since more than three decades now, reduced kinetic models like gyrokinetics, resulting from the elimination of the fast scales of motion associated with the particle rotation around magnetic field lines, are in the focus of intense research, both theoretical and numerical. First of all, because the gyrokinetic theory allows to exactly predict turbulent transport responsible for plasma deconfinement and second of all, since it allows a significant reduction of computational time for numerical simulations.

When the magnetic field is strong, it is natural to replace particles by their instantaneous centres of rotation around the magnetic field lines and therefore remove the fastest scale of rotation from the description of dynamics. It grounds the idea of the reduced kinetic (gyrokinetic) formalism. A multi-scaled asymptotic reduction procedure lies behind the construction of gyrokinetic dynamical reduction [1].

Using geometrical methods and in particular Hamiltonian framework for derivation of reduced models allows to control consistency at each order of reduction procedure and avoid appearance of unphysical terms. Moreover, "magic" cancellations in the Hamiltonian settings leading to simplification of the models are highly appreciated while developing large scale codes. In addition to that, using Hamiltonian framework allows identifying exactly conserved quantities associated to the reduced model, which can be used as rigorous code diagnostics for energy consistency.

In this talk derivation of the reduced kinetic models issued form the Hamiltonian formalism implemented in major large scale.

European codes will be presented together with rigorous diagnostics to the codes through implementation of exactly conserved properties. It will be shown how the knowledge of exact dynamics invariants allows to get better understanding of the fundamental instabilities mechanisms driving turbulence.

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