UCCS Department of Mathematics Colloquium

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High field limits for magnetized plasmas

ABSTRACT: Many research projects in plasma physics concern the energy production through thermo-nuclear fusion. The controlled fusion requires the confinement of the plasma into a bounded domain and for this we appeal to the magnetic confinement. Several models exist for describing the evolution of strongly magnetized plasmas : the guiding-center approximation, the finite Larmor radius regime, etc. The subject matter of this talk is to present asymptotic models in the general three dimensional setting under the action of large stationary inhomogeneous magnetic fields. The mathematical analysis relies on average techniques, related to ergodic theory and homogenization procedures. We propose a general method providing rigorous derivations for such models. One of the key points is to observe that the orthogonal projection on the kernel of a linear transport operator is given by the average along its characteristic flow. We use here the mean ergodic theorem of von Neumann. The computations simplify a lot when appropriate coordinates are chosen. In particular, to any prime integral of the dominant characteristic flow, we associate a derivation commuting with the average operator. At the leading order the particles are advected along the magnetic lines. The plasma remains confined around the magnetic lines. But perpendicular drifts occur at the next order (electric cross field drift, magnetic gradient drift, magnetic curvature drift), which may destroy the confinement. Therefore it is very important to compute them, in order to estimate the confinement time. Using similar techniques we can take into account the first order corrections and finally we propose a second order accurate model for the gyro-kinetic Vlasov equation.\\