Kinetic description of magnetized technological plasma

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Plasma processes like magnetically enhanced reactive ion etching (MERIE), plasma ion assisted deposition (PIAD), and conventional and high power im-pulse magnetron sputtering (dcMS/HiPIMS) employ magnetized high den-sity plasmas at relatively low pressures. (Typical values are $p \approx 0.1 - 1\,\mathrm{Pa}$, $B \approx 10 - 100\,\mathrm{mT}$, $n_\mathrm{e} \approx 10^{15} - 10^{20}\,\mathrm{m}^{-3}$.) Such plasmas are, at least in their active regions, characterized by a peculiar ordering of the dynamic length and corresponding time scales: $\lambda_D \lll s \lll r_\mathrm{L} \lll L \sim \lambda \lll \lambda^*$, with λ_D Debye length, s sheath thickness, r_L gyroradius, L system length, and λ and λ^* elastic and inelastic electron mean free path, respectively. This regime is very difficult to analyze. Fluid models do not apply and numerical kinetic approaches like particle-in-cell are rather expensive. An alternative may be "gyrokinetics". This theory - actually more a class of theories - was designed and successfully employed in the field of fusion plasmas. It relies on the insight that the fast gyro motion of magnetized particles can be mathemat-ically separated from the slower drift motion and be integrated out, leaving only the dynamics on slower time scales and larger length scales. Unfor-tunately, however, magnetized technical plasmas are considerably different from fusion plasmas: Differences concern the magnetic field topology, the the desired wall interactions, collisions with neutrals, the fact that only elec-trons are magnetized, etc. Direct application of theories developed for fusion is thus not possible. We will present a gyrokinetic theory for magnetized technical plasmas that is based on first principles. The outset is a general kinetic description of the electron component which incorporates the scaling mentioned above. A multi-time scale formalism is employed which results in four separate levels. Explicitly solving the first two levels and substituting into the last two gives the desired self-consistent transport theory on the slowest time and largest length scales. The approach shares features both with "bounced averaged gyrokinetics" (of fusion theory) and with "nonlocal theory" (of low temperature plasma physics).