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The Linearized Kinetic Equation – A Functional Analytic Approach[1]

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Kinetic models of plasma phenomena are difficult to address for two reasons. They i) are given as systems of nonlinear coupled integro-differential equations, and ii) involve generally six-dimensional distribution functions f(**r**,**v**,t). In situations which can be addressed in a linear regime, the first difficulty disappears, but the second one still poses considerable practical problems. This contribution presents an abstract approach to linearized kinetic theory which employs the methods of functional analysis. A kinetic electron equation with elastic electron-neutral interaction is studied in the electrostatic approximation. Under certain boundary conditions, a nonlinear functional, the kinetic free energy, exists which has the properties of a Lyapunov functional. In the linear regime, the functional becomes a quadratic form which motivates the definition of a bilinear scalar product, turning the space of all distribution functions into a Hilbert space. The linearized kinetic equation can then be described in terms of dynamical operators with well-defined properties. Abstract solutions can be constructed which have mathematically plausible properties. As an example, the formalism is applied to the example of the multipole resonance probe (MRP). Under the assumption of a Maxwellian background distribution, the kinetic model of that diagnostics device is compared to a previously investigated fluid model.

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