Numerical Modelling of the Thermal Force Effect in Fluid and Kinetic Plasma Transport Codes

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The effect of thermo diffusion has been discovered by David Enskog exactly a century ago during his doctoral thesis. In plasma physics this effect is important for the prediction of impurity ion flows. An example is the migration of eroded wall material in the hydrogen plasma of a magnetic fusion device. Thus common plasma transport codes in magnetic fusion research account for this effect, which can be modelled either in the fluid or in the more accurate kinetic approach. A simple fluid model for multispecies plasmas where the thermal force effect is included has been developed in Ref. [1] for boundary layer plasmas in fusion devices. This model has allowed to deduce a criterion for leakage of impurities from the core plasma, which is important for keeping magnetically confined plasmas clean. A quasi kinetic approach for treating thermal forces is summarized in Ref. [2]. Therein the thermal force is not represented kinetically, but with a fluid force converted to act on a single particle. The resulting algorithm is computationally extremely efficient and has found many applications for various impurity transport problems in fusion research. A fundamental kinetic approach has been introduced in Ref. [3], where the thermal force effect is treated from the collision point of view. In previous studies these three different models have been compared from the theoretical viewpoint, but what is still missing is a look on the range of application for practical simulations. For this purpose the fluid model for impurity transport developed in [1] will be taken as a reference and compared to the quasi kinetic particle transport model, which is outlined in chapter 6 in Ref. [2]. Finally both models will be confronted with the collision based kinetic approach outlined in [3], which has been recently further improved in [4]. Plasma parameters are sought where the three different approaches match. Moreover the limits of the fluid approach are discussed and when the quasi kinetic approach is required, and furthermore when a complete kinetic treatment is desirable.

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