**Relativistic effects in electron neoclassical transport**

I. Marushchenko, N.A. Azarenkov

*V. N. Karazin Kharkiv National University, Svobody Sq. 4, 61022, Kharkiv, Ukraine*

The common opinion about the negligible role of relativistic effects in transport physics is based on the assumption that those are important only for suprathermal electrons with energies $E \sim m_e c^2$, and all transport codes developed to date and applied for simulations of reactor scenarios are based on the non-relativistic approach. However, as was shown recently [1, 2], relativistic effects in collisional transport can appear even for $T_e$ about few tens keV, i.e. for ITER and DEMO parameters, and surely are non-negligible for future aneutronic fusion reactors, which require temperatures of about 70 keV.

Starting from the relativistic drift-kinetic equation (rDKE) [2], relativistic formulations for neoclassical radial and parallel electron fluxes of particles, energy and heat are obtained. Apart from the mono-energetic approach, which is sufficient for relativistic transport coefficients used in calculation of radial fluxes, the relativistic Spitzer problem is considered, whose solution is required for calculation of parallel flows and, in particular, for the bootstrap current. The standard approach of expanding the energy dependence of perturbation of the distribution function in Sonine (associated Laguerre) polynomials $L_{k}^{3/2}$ becomes inconvenient, since, due to the additional relativistic correction term in the 1-st thermodynamical force, it requires an additional expansion. Instead, the solution of rDKE can be expanded in Sonine polynomials of arbitrary order, $L_{k}^{\alpha}$, with $\alpha = 3/2 + R$, and $R = \mu_r(K_3/K_2 - 1) - 5/2 \approx 15/(8\mu_r) + O(\mu_r)$ is the relativistic correction term, which gives precisely the same accuracy. Here, $\mu_r = m_e c^2/T_e$, where $m_e$ and $T_e$ are the mass and the temperature of electrons, correspondingly, $c$ is the speed of light, and $K_n(\mu_r)$ is the modified Bessel function of second kind of the n-th order.

The main advantage of the proposed approach is the possibility to take the relativistic effects into account without making any significant changes in transport solvers. With the proper choice of parameters and right-hand-side of drift-kinetic equation [2], mono-energetic transport coefficients obtained by any non-relativistic solver can be re-interpreted as the relativistic ones and then used for the calculation of energy convolution according to relativistic formula.

**References**
