On Nonlocal Transport Based Closure Relations for Radiation Hydrodynamics

M. Holec[†‡], **R. Liska**[‡], **S. Weber**[†]

[†] ELI-Beamlines, Institute of Physics, AS CR, v.v.i,
Na Slovance 2, Praha 8, 180 00, Czech Republic
(milan.holec@eli-beams.eu, stefan.weber@eli-beams.eu)

[‡] Department of Physical Electronics, Faculty of Nuclear Sciences and Physical Engineering,
Czech Technical University in Prague,
Břehová 7, Praha 1, 115 19, Czech Republic
(liska@siduri.fjfi.cvut.cz)

Keywords: radiation hydrodynamics; closure relations; nonlocal transport; Bhatnagar-Gross-Krook collision operator; higher order methods; diffusion asymptotic; discontinuous Galerkin.

ABSTRACT

The nonlocal theory of the energy transport in radiative plasmas of arbitrary ratio of the characteristic spatial scale length to the photon and electron mean free paths is applied to define the closure relations of hydrodynamic system. The corresponding transport phenomena cannot be described accurately with the usual fluid approach dealing only with local values and derivatives. Thus, the parabolic terms like viscous force and energy flux are calculated directly by solving a simplified transport equation allowing one to take into account the effect of long-range particle transport. The key feature of the proposed method is the application of the Bhatnagar-Gross-Krook collision operator delivering a calculation efficiency and an inherent coupling to the fluid plasma parameters in an implicit way. In combination with a higher order discontinuous Galerkin scheme of the transport equation, the solution obeys both limiting cases, i.e. the collisional diffusion asymptotic usually present in radiation hydrodynamics models and the collisionless transport of free-streaming particles. As a result we present a robust method to model the energy transport exhibiting a correct physical behavior controlled by the particles mean free path.