Efficient 3D radiative transfer modeling of scattering polarization

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We present an efficient and massively parallel solution strategy for the transfer problem of polarized radiation, for a 3D stationary medium out of local thermodynamic equilibrium. Scattering processes are included accounting for partial frequency redistribution effects. Such a setting is one of the most challenging ones in radiative transfer modeling. The problem is formulated for a two-level atomic model, which allows linearization. The discrete ordinate method alongside an exponential integrator are used for discretization. Efficient solution is obtained with a Krylov method equipped with a tailored physics-based preconditioner. A matrix-free approach results in a lightweight implementation, suited for tackling large problems. Near-optimal strong and weak scalability are obtained with two complementary decompositions of the computational domain. The presented approach made it possible to perform simulations for the Ca I line at 4227Å with more than 40 billions degrees of freedom in few hours on massively parallel machines, always converging in a few iterations for the proposed tests.