Very Fast Iterative Methods for Radiative Transfer Applications

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The development of novel Radiative Transfer (RT) methods often leads to important breakthroughs in astrophysical plasma spectroscopy, because they allow the investigation of problems that could not be properly tackled using the methods previously available. This RT topic is also of great interest for the "Promise of FIRST" because a rigorous interpretation of the observations will require to carry out detailed confrontations with the results from Non-LTE RT simulations in one-, two-, and three-dimensional geometries.
The efficient solution of Non-LTE multilevel RT problems requires the combination of a highly convergent iterative scheme with a very fast formal solver of the RT equation. This applies to the case of unpolarized radiation in atomic lines, to the promising topic of the generation and transfer of polarized radiation in magnetized plasmas and to RT in molecular lines.
The "dream" of numerical RT is to develop iterative methods where everything goes as simply as with the so-called Λ-iteration scheme, but for which the convergence rate is extremely high. In this contribution we will describe novel RT methods based on Gauss-Seidel iteration. These methods are of interest because they allow to solve a given RT problem with an order-of-magnitude of improvement in the total computational work with respect to the standard ALI method. We will show that their convergence rate is very high, that they do NOT require the construction and the inversion of any large matrix and that the computing time per iteration is very small (i.e. similar to that of the $\Lambda-$iteration method). We will show illustrative results for the case of unpolarized radiation in atomic lines (in 1D, 2D and 3D with multilevel atoms) and also for the case of the transfer of polarized radiation in magnetized plasmas. The case of RT in molecular lines will be presented in an extra contribution at this conference by Asensio Ramos, Trujillo Bueno and Cernicharo.