CO-MOVING FRAME SIMULATIONS OF LINE EMISSION FROM MAGNETOSPHERIC ACCRETION.

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Simulations of line profiles from magnetospheric accretion is a non-LTE problem that requires the solution of the statistical equilibrium of the species under consideration, followed by an integral of the radiative-transfer equation for a particular viewing angle. The magnetosphere may be a two (axisymmetric) or three-dimensional structure, and that the accreting material is following a complex velocity field, the solution of the above equations is non-trivial.

Until now the statistical equilibrium has been calculated under the Sobolev, or large velocity gradient, approximation. This approximation requires that the length scale over which the physical conditions of the gas change is significantly larger than the distance over which the velocity changes by the thermal line-width. Line profiles computed using this approximation display many of the characteristics of the observed profiles (e.g. Muzerolle et al. 1998, ApJ 492, 743; Muzerolle et al. 2001, ApJ, 550, 944; Symington et al. 2005, MNRAS, 356, 1489; Kurosawa et al. 2006, MNRAS, 370, 580). Despite these successes, detailed comparisons of the line profiles with observations needed to be treated with caution since the central (low velocity) part of the line profile is generated in a region where the velocity gradient is small and the Sobolev approximation in invalid.

We have developed a model that solves the statistical equililbrium (SE) for hydrogen and helium using a co-moving frame long-characteristic method based on the accelerated Monte-Carlo algorithm of (Hogerheijde & van der Tak, 2000, A&A, 362, 69). A set of rays is traced from the centre of each grid cell to the boundary in order to sample the external radiation field, and the radiation-field local to the cell, and the level populations in the cell, are iterated to convergence under the boundary condition given by the external field. Once the SE equation has been solved for every cell in the grid the convergence is examined, and another iteration is performed, if necessary also increasing the number of rays used to calculate the external radiation field. The separation of the internal and external radiation fields for each cell is analogous to the traditional accelerated lambda iteration approach (Rydbicki & Hummer 1991, A&A, 245, 171), which vastly speeds up convergence of the radiation field and level populations.

We present the algorithm in detail, and some sample calculations of hydrogen and helium line profiles from a typical magnetosphere.