

DIFFUSION APPROXIMATION IN A RADIATIVE TRANSFER MODEL FOR ASTROPHYSICAL FLOWS

LAURENT DI MENZA¹, CLAIRE MICHAUT² AND OCÉANE SAINCIR³

Abstract. In this work, we present the diffusion approximation model for radiative transfer when we deal with optically thick astrophysical flows. Since the initial model is high CPU time demanding when dealing with its numerical approximation, solving this simpler system can provide a low cost strategy for the simulation of radiative media. We then use a finite-volume algorithm coupled with an implicit scheme for radiative contributions to solve this simplified system. Numerical experiments in the one-dimensional and two dimensional cases are presented to validate our numerical strategy and to prove the relevance of this asymptotic model.

Résumé. Nous présentons dans ce travail un modèle du régime de la diffusion pour le transfert radiatif dans le cas où le milieu est optiquement très épais pour la description d'écoulements astrophysiques. Ce modèle permet d'envisager des stratégies numériques moins coûteuses en temps que le modèle M1 pour la simulation de processus radiatifs. Nous utilisons pour cela une méthode de type volumes finis couplée à un schéma implicite pour les termes de rayonnement et nous présentons des résultats de simulations numériques en dimension 1 et 2 d'espace permettant de valider notre algorithme et de montrer la pertinence de ce modèle.

1. INTRODUCTION

The comprehension of realistic astrophysical phenomena has been the subject of many challenging studies for decades, with various applications in stellar physics such as the study of jets in the formation of young stars involving matter accretion, stellar winds and dynamics of supernova remnants. Within this framework, a wide complexity occurs for different reasons. First, these phenomena involve both hydrodynamics and radiative processes (see [16], [18], [23]). The latter ones are driven by the propagation of photons at the speed of light, which means that typical velocities completely differ between hydrodynamic and radiation scales. This causes a strong coupling between fluid and radiation since the behavior of the medium at a given point may depend on quantities which need to be evaluated on a large spatial zone (the physical effects are said to be *nonlocal*). Moreover, in the general case the analytical expression for the physical values under study is out of reach due to the complexity of the governing model. In this case, one can use numerical methods in order to simulate the physical phenomena as accurately as possible. Consequently, mathematical algorithms that are involved have to be consistent with the desired solutions (see [21]). In particular, they have to tolerate discontinuities that may spatially propagate (known as "shock waves") and they have to produce physically relevant results (namely

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