

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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Astrophysical Flows Andrew King

James E. Pringle, Andrew King



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summarizes the status of the study of astrophysical black hole research and is aimed at astrophysicists and graduate students working in this field Originally published in Space Science Reviews Vol 183 1 4 2014 **The Observatory** ,1997 Black Hole Formation and Growth Tiziana Di Matteo,Andrew King,Neil J. Cornish,2019-10-31 The ultimate proofs that black holes exist have been obtained very recently thanks to the detection of gravitational waves from their coalescence and due to material orbiting at a distance of some gravitational radii imaged by optical interferometry or X ray reverberation mapping This book provides three comprehensive and up to date reviews covering the gravitational wave breakthrough our understanding of accretion and feedback in supermassive black holes and the relevance of black holes for the Universe since the Big Bang Neil J Cornish presents gravitational wave emission from black hole mergers and the physics of detection Andrew King reviews the physics of accretion on to supermassive black holes and their feedback on host galaxies Tiziana Di Matteo addresses our understanding of black hole formation at cosmic dawn the emergence of the first quasars black hole merging and structure formation The topics covered by the 48th Saas Fee Course provide a broad overview of the importance of black holes in modern astrophysics Revista Mexicana de Astronomía Y Astrofísica ,1995 *IAU Colloquium 194* Gagrik Tovmassian,Edward M. Sion,2004 *Science* John Michels (Journalist),2011

Astrophysical Flows Andrew King: Bestsellers in 2023 The year 2023 has witnessed a remarkable surge in literary brilliance, with numerous compelling novels captivating the hearts of readers worldwide. Lets delve into the realm of bestselling books, exploring the captivating narratives that have captivated audiences this year. The Must-Read : Colleen Hoovers "It Ends with Us" This heartfelt tale of love, loss, and resilience has captivated readers with its raw and emotional exploration of domestic abuse. Hoover masterfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can triumph. Uncover the Best : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This captivating historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids absorbing storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Discover the Magic : Delia Owens "Where the Crawdads Sing" This mesmerizing coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens crafts a tale of resilience, survival, and the transformative power of nature, entrancing readers with its evocative prose and mesmerizing setting. These popular novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of captivating stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a masterful and suspenseful novel that will keep you speculating until the very end. The novel is a cautionary tale about the dangers of obsession and the power of evil.

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