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ORIGINAL ARTICLE

Relativistic collapsing radiating stars

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Abstract A new class of exact solutions of Einstein's equations is proposed for a collapsing radiating spherically symmetric shear-free isotropic fluid undergoing radial heat flow. In remote past the solutions are static perfect fluid which then gradually starts evolving into radiating collapse. The interior solutions are matched with Vaidya exterior metric over the boundary.

Keywords Exact solutions · Gravitational collapse · Radiating star · Black hole

1 Introduction

The detailed description of gravitational collapse and modeling of the structure of compact objects under different conditions, is one of the most interesting problem in general relativity. The study of gravitational collapse was started by Oppenheimer and Snyder (1939), in which they assumed a spherically symmetric distribution of matter, adiabatic flow and the equation of state in the form of dust with Schwarzschild exterior. Later on the case with static exterior was studied by Misner and Sharp (1964) for a perfect fluid in the interior. It is already established fact that gravitational collapse is highly dissipating energy process (Herrera and Santos 2004; Herrera et al. 2004b; Mitra 2006) which plays a dominant role in the formation and evolution of stars. However, the dissipation of energy from collapsing fluid distribution is described in two limiting cases. The first case describes the free streaming approximation and the dissipation is modeled by means of an out-flowing null fluid while second one is diffusion approximation and in this case the dissipation is modeled by heat flow type vector.

Vaidya (1951a, 1951b, 1966) initiated the problem for physically meaningful models of radiating fluid. On the similar ground a number of models have been proposed by Tewari (1988, 1994, 2006, 2010), Pant and Tewari (1990, 2011) by solving the modified equations proposed by Misner (1965), Lindquist et al. (1965) for an adiabatic distribution of matter. Moreover, Herrera et al. (1980) presented a new approach to the study of a non-static radiating fluid. The model proposed by Glass (1981) has been extensively studied by Santos (1985) for the junction conditions of collapsing spherically symmetric shear-free non-adiabatic fluid with radial heat flow. A number of studies have been reported by de Oliveira et al. (1985, 1988), de Oliveira and Santos (1987), Bonnor et al. (1989), Kramer (1992), Maharaj and Govender (1997, 2005), Banergee et al. (2002), Debnath et al. (2005), Herrera et al. (1998, 2004a, 2004b, 2006, 2007, 2009), Naidu and Govender (2007) and also references there in for describing a collapsing fluid radiating energy.

In this paper, in light of relevant physical and thermodynamic conditions we present new exact solutions of Einstein's equations for spherically symmetric non-adiabatic collapsing fluid with radial heat flux. The interior space-time metric is matched with Vaidya exterior metric (Vaidya 1953) at boundary. The interior solutions represent in the infinite past static perfect fluid which gradually starts into radiating collapse.

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