

General radially moving references frames in the black hole background

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We consider general radially moving frames realized in the background of nonextremal black holes having causal structure similar to that of the Schwarzschild metric. In doing so, we generalize the Lemaître approach, constructing free-falling frames which are built from the reference particles with an arbitrary specific energy e_0 including $e_0 < 0$ and a special case $e_0 = 0$. The general formula of 3-velocity of a freely falling particle with the specific energy e with respect to a frame with is presented. Using our radially moving frames, we consider also nonradial motion of test particles including the regions near the horizon and singularity. We also point out the properties of the Lemaître time at horizons depending on the frame and sign of particle energy.

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