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Aspects of neutrino mass hierarchy in gravitational lensing

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It is now clear beyond any doubt that neutrinos have masses, and that they mix. Experiments with solar, atmospheric, reactor and accelerator neutrinos have determined, with remarkable accuracy, values of $\Delta m^2_{ij} = m^2_i - m^2_j$. Absolute neutrino masses, however, are still unknown. We know neutrino vacuum oscillations only depend on Δm^2, hence, oscillations experiments are inadequate of providing information about absolute neutrino masses. In our work, we show that the lensing of neutrinos induced by a gravitational source substantially modifies this standard picture and it gives rise to a novel contribution through which the oscillation probabilities also depend on the individual neutrino masses. We show that the oscillation probability in the presence of lensing is sensitive to the absolute masses of neutrinos and sign of Δm^2_{ij}, unlike in the case of standard vacuum oscillation in flat spacetime. We demonstrate this explicitly by considering an example of weak lensing induced by a Schwarzschild mass and discuss various implications of gravitationally modified neutrino oscillations and means of observing them.
Further, We study decoherence effects in neutrino flavour oscillations in Schwarzschild geometry with particular emphasis on the lensing. Assuming Gaussian wave packets, we show that the decoherence is sensitive to the absolute values of neutrino masses as well as the classical trajectories taken by neutrinos between the source and detector along with the spatial widths of neutrino wave packets. We show that in presence of a Schwarzschild object the neutrino wave packets decohere later in comparison when the Schwarzschild object is absent. At distances beyond the decoherence length, flavour transition probability attains a value that depends only on the leptonic mixing parameters. Hence, the observability of neutrino lensing significantly depends on these parameters and in-turn the lensing can provide useful information about the latter.
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