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Entanglement in anisotropic spacetime

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The advent of quantum theory of information stimulated investigations across traditional frontiers. Among others we are witnessing an extension of quantum information notions into the general relativity framework. As a consequence entanglement, being recognized as a fundamental resource in quantum information processing, has been widely investigated in curved spacetime. In particular it has been realized the possibility of generating it by the expansion of universe. This effect can be traced back to the mechanism of particle-antiparticle production during cosmic evolution. The vast majority of studies along this line focus on homogeneous and isotropic spacetime, that is, using a Friedman-Robertson-Walker (FRW) background. However our universe is neither homogeneous nor isotropic: there are structures in it, galaxies, clusters of galaxies, super-clusters, etc. which causes deviations of the FWR background. Even in the very early universe one expects quantum fluctuations from this FWR background to occur. Then an interesting question is if we could in principle observe by means of particle correlations any departure from homogeneity and isotropy. Thus we want at least partially release the symmetry assumptions for the metric and consider anisotropy, i.e. a metric whose space part depends the direction. Dealing with anisotropic spacetime models present technical difficulties and solutions can only be pursued by resorting to perturbative approaches. In this way entanglement for the scalar field has been recently studied by us in the anisotropic spacetime context. Here we present an enlarged study that encompasses also the Dirac field and provides a comparison between the two cases (spin-less and spin-1/2 field). We found there marked differences between scalar and Dirac fields for the massive case and similarities for the massless case. In fact, while for massive scalar field revivals of entanglement entropy vs momentum appear after decreasing from the maximum at $k = 0$, in the massive Dirac field we find just a slight distortion of the non-monotonic profile giving rise to the maximum of entanglement entropy at $k > 0$. In contrast, it turns out that massless field of both type can only get entangled through anisotropy, with a maximum of entanglement entropy occurring at $k > 0$.

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