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Entanglement Enabled Spin Interference

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In quantum mechanics, interference traditionally occurs only between indistinguishable particles. In stellar intensity interferometry, this means measuring two photons of the same wavelength (color), and in high energy experiments it means femtoscopic correlation measurements must investigate pairs of identical particles ($\pi^+\pi^+$, $\pi^-\pi^-$ etc.). However, nearly a decade ago Cotler and Wilczek proposed a quantum device which utilizes entanglement to enable optical intensity interferometry between photons of different wavelengths, suggesting that certain forms of entanglement make interference of non-identical quantum particles possible. Recently, a spin interference phenomenon was discovered in ultra-peripheral heavy-ion collisions through photonuclear production of $\rho^0 \to \pi^+\pi^-$ pairs. In this process interference is observed even through the final observation is a $\pi^+\pi^-$ pair - pions of clearly distinguishable charge. Besides its novelty as a general quantum phenomenon, this discovery of entanglement enabled spin interference in the angular distribution of $\rho^0 \to \pi^+\pi^-$ from diffractive photonuclear interactions has opened new avenues for investigating the gluon distributions in heavy nuclei and for studying the structure of heavy nuclei at high energy. In this talk I will review the experimental discovery and goals of the ongoing experimental measurements from various collaborations. Finally, I will discuss the emerging theoretical description of this novel phenomenon and comment on the various theoretical calculations that have appeared recently.

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