Tomography of ultra-relativistic nuclei with polarized photon-gluon collisions

Zhangbu Xu for the STAR Collaboration

A linearly polarized photon can be quantized from the Lorentz-boosted electromagnetic field of a nucleus traveling at ultra-relativistic speed. When two relativistic heavy nuclei pass one another at a distance of a few nuclear radii, the photon from one nucleus may interact through a virtual quark-antiquark pair with gluons from the other nucleus forming a short-lived vector meson (e.g. ρ^0). In this experiment, the polarization was utilized in diffractive photoproduction to observe a unique spin interference pattern in the angular distribution of $\rho^0 \rightarrow \pi^+\pi^-$ decays. The observed interference is a result of an overlap of two wave functions at a distance an order of magnitude larger than the ρ^0 travel distance within its lifetime. The strong-interaction nuclear radii were extracted from these diffractive interactions, and found to be 6.53 ± 0.06 fm (^{197}Au) and 7.29 ± 0.08 fm (^{238}U), larger than the nuclear charge radii. The observable is demonstrated to be sensitive to the nuclear geometry and quantum interference of non-identical particles.
Reference: M. S. Abdallah et al. (STAR), arXiv:2204.01625