One of the standard approaches to estimate the magnetic field intensity in nucleus-nucleus collisions is to utilize cascade models, e.g. HIJING, JAM, etc. A result showing the time evolution of the field is presented below. The cascade models predict the main component of the field is generated by the spectator nucleons, leading to the peripheral collisions to reach the maximum field intensity. The spectator component grows with the beam energy in proportion to the [J/], while its lifetime gets inversely-proportionally shorter. Another component by the participant nucleons, or by the rotating fireballs after the collisions, is found to have lower peak intensities, but with longer lifetimes. A hydro-dynamical model with local velocity distributions as an initial condition is desired for a better description of the possibly long-lived participant contribution, as the evolution of the component by the “perfect fluid” fireball may not be very properly handled in the present cascade models.

Anisotropic Decay of Virtual Photons into Di-Electrons

Polarization of direct virtual photons is searched for, via their anisotropic decay into e+e−. The anisotropy is measured with respect to the reaction plane, determined with the ALICE V0 detectors, as a function of invariant mass of e+e− pair, and with centrality slices. The magnetic field is supposed to be perpendicular to the reaction plane. The detector effect is corrected by comparing the asymmetry in e+e− pairs (nearly) transverse to the field with that in pairs (nearly) parallel to the field. The latter is expected to show only the detector effect, since no linear polarization can exist due to a magnetic field parallel to a (virtual) photon.

All e+e− pairs are first categorized according to the azimuthal angle measured from the reaction plane, either as (nearly) perpendicular to the field, where physics polarization is expected, or as (nearly) parallel to the field, where no physics polarization is expected. The two sets of e+e− pairs are then further categorized in terms of the decay plane into e+e− and e−e−, either as (nearly) azimuthal in a (virtual) photon momentum direction) or as (nearly) longitudinal (in the reaction plane/vector). The acceptance corrected polarization is calculated from the ratios of the numbers of e+e− pairs in the four categories. As the kinematic parameter to separate azimuthal and longitudinal decay is not necessarily unique, we have tried and investigated 4 candidate parameters. A simple Monte Carlo simulation has been performed to confirm the method of acceptance correction and to evaluate the 4 candidate kinematic parameters. The candidate kinematic parameters “2” and “4” are found to have better discrimination for 3 extreme physics scenarios: no polarization, full polarization parallel to the magnetic field, and full polarization perpendicular to the field.

Summary and Prospects

The polarization is expected to be more prominent in mass regions above the e+e− mass where the fraction of direct virtual photons is higher, and in semi-central collisions where the most intense magnetic field is created. A very low mass region, e.g. < 30 MeV/c2, should serve as a reference, as it is dominated by Dalitz decay e+e− pairs (created in a late stage) and no polarization is expected. The values obtained using the kinematic variables “2” and “4”, are consistent with 0 and also with 1. The anisotropy decay into di-electrons, while none of current heavy ion experiments at LHC or RHIC is capable of measuring that of real photons. QED calculations of vacuum polarization tensors of photons indicate the effect can reach the order of 0.1% with the field intensity expected at LHC, which is within an experimental reach (K.Lishkawa, D.Kimura, K.Shibagki, A.Tsuji, Int. J. Mod. Phys. A28 (2013) 1350100).

New approaches to detect the magnetic field via di-electron asymmetry measurements are proposed and their experimental feasibilities are examined.

(1) anisotropic decay of virtual photons into di-electrons. Photons get polarized in a magnetic field. Thus, virtual photons is an especially promising probe, detectable via their anisotropic decay into di-electrons, while none of current heavy ion experiments at LHC or RHIC is capable of measuring that of real photons. QED calculations of vacuum polarization tensors of photons indicate the effect can reach the order of 0.1% with the field intensity expected at LHC, which is within an experimental reach (K. Lishkawa, D. Kimura, K. Shigaki, A. Tsuji, Int. J. Mod. Phys. A28 (2013) 1350100).

(2) aligned deflection of low-mass electron-positron pairs. The intense magnetic field serves just like a tiny magnetic spectrometer deflecting charged particles in accordance with their charge-sign and mass. The width of this spectrometer is very short in the very high field intensity, making the bending angle for particles – 1 GeV/c to be – 1 degree, which is again within an experimental reach with ALICE. The aligned deflection can be detectable by looking at correlated unlike charge sign pairs, e.g. e+e− from low-mass virtual photon decay.

Field Intensity Estimation

The intensity of a field is estimated by comparing the asymmetry in e+e− pairs (nearly) transverse to the field with that in pairs (nearly) parallel to the field. The latter is expected to show only the detector effect, since no linear polarization can exist due to a magnetic field parallel to a (virtual) photon.

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