Predicted experimental test will clarify how light interacts with matter at high energies

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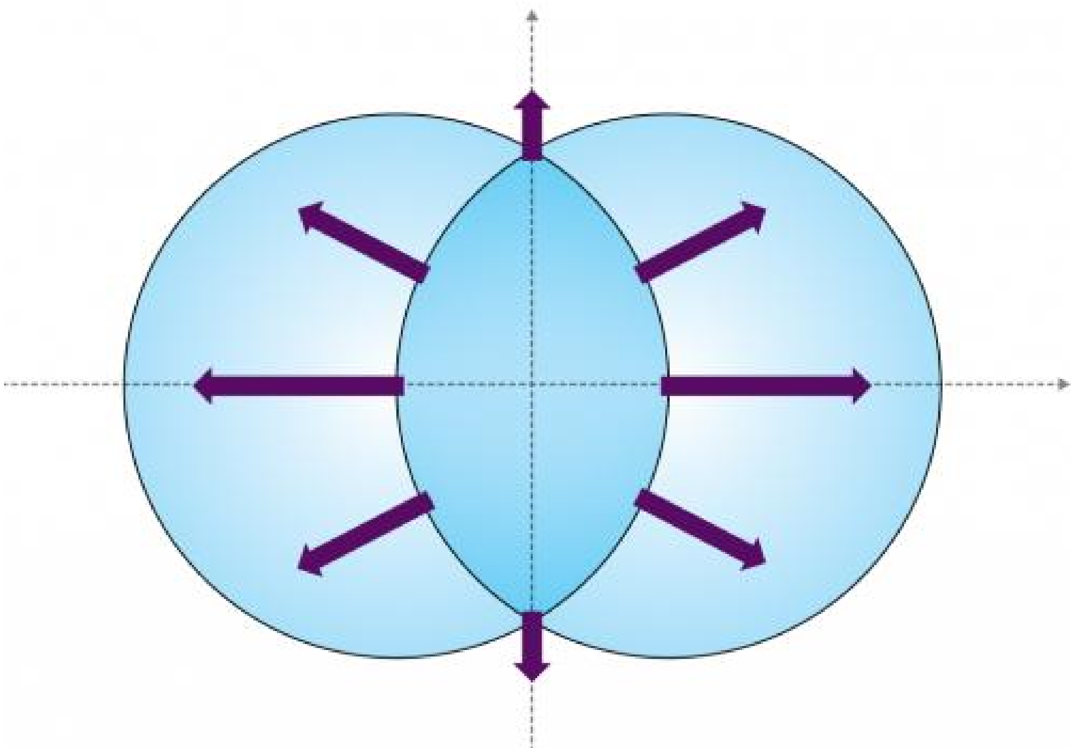

Figure 1: The uneven shape of a quark–gluon plasma. The arrows indicate the directions and momentums of particles produced by atomic collisions. Credit: 2013 Adam Bzdak and Vladimir Skokov, RIKEN BNL Research Center

Collisions of atomic and subatomic particles at very high energies reveal important properties about the beginning of the Universe and the atomic forces, and how fundamental particles are formed and react with each other. Adam Bzdak from the RIKEN BNL Research Center and colleague Vladimir Skokov from Brookhaven National Laboratory in the US have now proposed a scheme that allows for a better understanding of how light and subatomic particles react with each other during such high-energy collisions.

At the very early stages of the Universe there were no atoms: energies were so high that atoms would have been torn apart. Instead, there was a mix of subatomic particles such as gluons and quarks. These make up the protons and neutrons inside atomic cores, but at very high energies they form a hot cloud known as a quark–gluon plasma. These plasmas can also be produced artificially by smashing heavy atoms together, as is currently being performed by the PHENIX Collaboration at the Relativistic Heavy Ion Collider at Brookhaven.

In these experiments, it has been observed that light (photons) emanating from the collision zone varies in intensity depending on the direction of light emission (Fig. 1). This uneven distribution of photons is similar to the pattern expected for a quark–gluon plasma, which has surprised scientists. "Photons do not interact with the created matter and cannot be sensitive to the shape of the fireball," says Bzdak. "This is a clear paradox and so far there is no compelling explanation. Clearly we do not understand something very basic."

Although several theories, such as the role of magnetic fields, have been proposed that could explain this effect, a clear explanation has not been possible. Bzdak and Skokov have now proposed a scheme that aims to identify whether magnetic fields are indeed responsible, or whether photons are simply produced non-uniformly during the collisions. Their theoretical study compares the emission patterns of photons for different shapes of the quark–gluon plasma and different numbers of particles creating magnetic fields. If the emission pattern of the photons follows that of the different quark–gluon plasma, it would verify the direct connection between the two phenomena.

The experimental verification of their proposal will be the next step, says Bzdak. "I believe our job is done and now the ball is in the experimentalists' court. The implementation of our scheme is quite straightforward and is currently being studied by the PHENIX Collaboration."

More information: Bzdak, A. & Skokov, V. Anisotropy of photon production: Initial eccentricity or magnetic field. *Physical Review Letters* 110, 192301 (2013). dx.doi.org/10.1103/PhysRevLett.110.192301

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