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Azimuthally-anisotropic photon spectrum induced by chiral anomaly in strong magnetic fields

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It has been known for a long time that neutral-pions dominantly decay into two photons,
which was subsequently understood on a robust theoretical basis after the discovery of chiral anomaly.
A theorem shown in a seminal paper by Adler and Bardeen [1] indicates
that a neutral pion is coupled to only two-photon states without couplings to other multi-photon states.
When chiral anomaly is tied to extremely strong magnetic fields created in ultrarelativistic heavy-ion collisions [2],
we find
that transition between a neutral pion and a photon becomes possible
with one of the two photons replaced by an external magnetic field.
The theorem allows us to obtain the transition amplitude governed by chiral anomaly without theoretical ambiguities.

We discuss attainable signatures of the anomaly-induced transition
between neutral pions and photons in RHIC and LHC experiments.
Although the magnetic fields persist for $1\,\mathrm{fm}/c$ or even shorter duration
after the heavy ion collisions,
we still find a photon source having much chance to interact with the magnetic field,
that is, the prompt photon emitted just at the impacts of the collisions.
While the prompt real photons propagate in the magnetic field,
a part of the photons is converted into neutral pions, leaving an reduced amount of photons.
Then, we show that the prompt photons to be measured in the experiments
should have a negative v_2 and particular polarizations [3],
since the transition amplitude is azimuthally anisotropic and depends on the photon polarizations
due to a preferred orientation prescribed by the external magnetic fields.
We propose that analyses on those observables should be performed in the future experiments,
which makes the creation of the strong magnetic fields evident,
while major attention has been conventionally paid to the total yield of prompt photons.
We take into account the time dependence of the magnetic fields,
and show the beam energy and impact parameter dependences of
the photon's v_2 and polarizations.

This work will provide impacts on elucidating formation of the prompt-photon spectrum
as a penetrating probe from the very early stage,
and thus shed light on an aspect of the early-time dynamics in the heavy-ion collisions.

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