The fraction of photon energy lost by the emission of a gravitational wave in the magnetic field of colliding heavy ions is 10^{-37} … at most.

On the gravitational wave emission in the magnetic field of a heavy-ion collision

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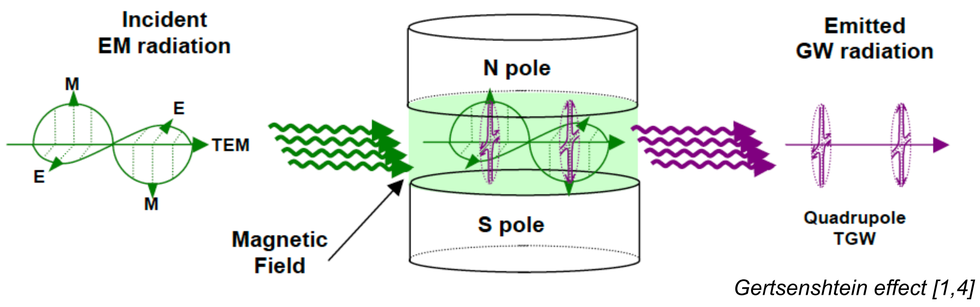
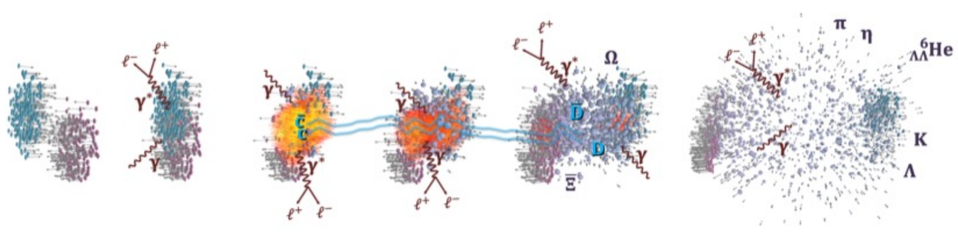


Gertsenshtein effect [1,4]

- In 1961 **Gertsenshtein** [1] demonstrated that an electromagnetic wave (EMW) can be transformed into a gravitational wave (GW) when propagating through an external, transverse magnetic field.
- In 1973 **Zel'dovich** calculated the fraction of energy of an electromagnetic wave transformed into the energy of a gravitational wave in a conversion process EMW→GW →EMW in astrophysical situations [2].
- In 2019 the Ultra-High-Frequency Gravitational Wave (UHF-GW) initiative [3] is launched to stimulate the technological development that is needed to build successful gravitational wave detectors at high frequency.

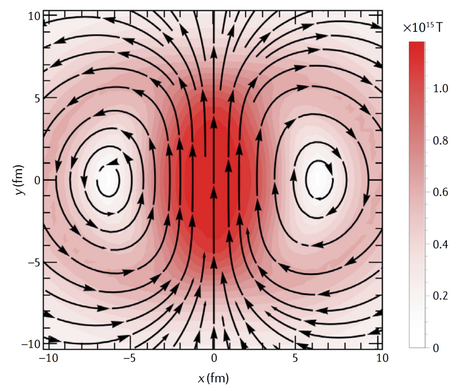


Au+Au collision as calculated with the UrQMD model [5]

- In a heavy ion collision, photons are created in all its stages.
- At the same time extremely strong magnetic fields are induced reaching 10^{14} -10^{15} T. Can we use these fields to generate or detect UHF-GW?
- Photons emitted in heavy ion collisions should be redshifted → energy loss by emission of a GW in the magnetic field.

- The fraction of energy of a EMW transformed into the energy of a GW in the field H_0 along the path length R *[2]:*

$$\alpha = \frac{G H_0^2 R^2}{c^4}$$

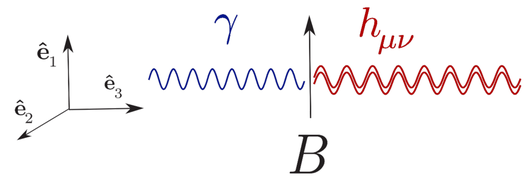


Simulation of the magnetic field for Au-Au collisions at RHIC [6]

- Several assumptions and simplifications (best case scenario):
  - Static magnetic field,
  - Vacuum → coherence of EMW and GW,
  - Extension of the magnetic field of $\mathcal{O}$(fm).
- For heavy ion collisions:

$$\alpha \approx 10^{-37}$$

- Certainly, this is not within our reach, but new ideas are needed – can we make use of the largest magnetic fields in the world?
- UHF-GW are messengers of new physics. Any discovery of gravitational waves at high frequencies would indicate new physics!
- The generation and control of gravitational waves would lead to significant and dramatic advancements in space communication.



References:
[1] M. E. Gertsenshtein, J. Exptl. Theoret. Phys. (U.S.S.R.) 41, 113-114 (1961)
[2] Ya. B. Zel'dovich, Sov. Phys. JETP, Vol. 38, No.4 (1974)
[3] N. Aggarwal, O.D. Aguiar, A. Bauswein et al., Living Rev Relativ 24, 4 (2021)
[4] G.V. Stephenson, AIP Conference Proceedings, 746 (1) 1264 (2005)
[5] Figure credit: T. Galatyuk and F. Seck
[6] D.E. Kharzeev, J. Liao, Nat Rev Phys 3, 55–63 (2021)