On the Origin of Cosmological Magnetic Fields

Kiyotomo Ichiki[1], Keitaro Takahashi[2], Hiroshi Ohno[3], Hanayama Hidekazu[4], and Naoshi Sugiyama[1]

[1] *National Astronomical Observatory, 2-21-1, Osawa, Mitaka, Tokyo 181-8588,Japan*

[2] *Department of Physics, Princeton University, Princeton, NJ 08544, USA*

[3] *Corporate Research and Development Center, Toshiba Corporation, Kawasaki 212-8582, Japan*

[4] *Department of Astronomy, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan*

The presence of substantial magnetic fields in galaxies and even on larger scales such as in clusters of galaxies is observationally indicated. The origin of such magnetic fields with large coherent length, however, is still one of the biggest mysteries in cosmology. Several models have been proposed to explain the origin, which are often involved with inflation in the early universe, or astrophysical activities during the structure formation of the universe until today. Here we propose a new mechanism for generation of magnetic fields [1, 2]. We showed that cosmological density fluctuations, which explain the large scale structure of the universe and cosmic microwave background temperature anisotropies, can also produce sufficient amount of magnetic fields on the cosmological scales at the epoch of recombination if we take the second order couplings into account. Evaluating the power spectrum of magnetic fields we found that the fields of $10^{-16.8}$ Gauss are created at 1 Mpc scale and can be even stronger at smaller scales (Fig. 1). These fields should inevitably exist since we do not introduce any arbitrary assumptions. The magnetic fields generated in this mechanism may affect the formation of the primordial stars in the universe and be observed through time delays in pulses of gamma rays.

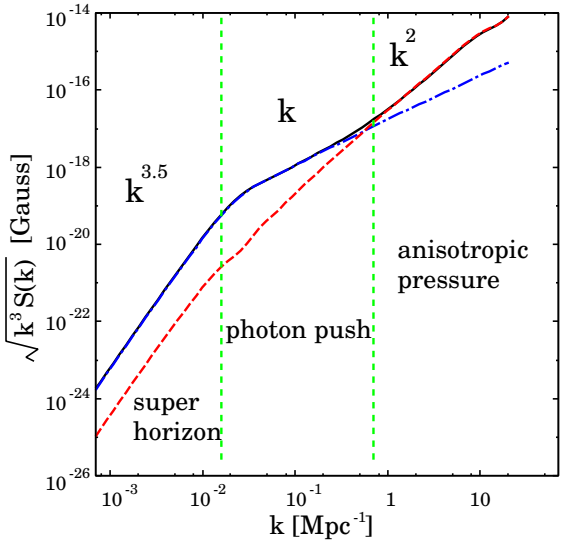

Figure 1: Spectrum of magnetic fields S(k) generated from cosmological perturbations at $z = 10^3$. Dashed and Dot-dashed lines show contributions from the baryon-photon slip and photon's anisotropic stress, respectively. The spectrum decays as k^4 at scales larger than that of the cosmic horizon at cosmological recombination. At small scales, the contribution from the anisotropic stress of photons dominates and the spectrum has a slope proportional to k.

References

[1] K. Takahashi, K. Ichiki, H. Ohno and H. Hanayama, *Phys. Rev. Lett.*, **95**, 121301 (2005).

[2] K. Ichiki, K. Takahashi, H. Ohno, H. Hanayama and N. Sugiyama, *Science*, in press.