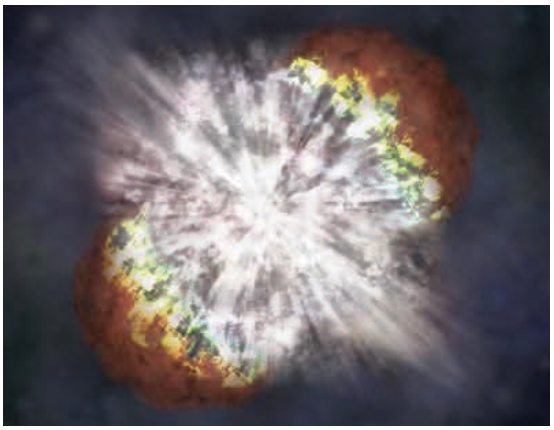
Physics and Space Sciences Department Colloquium Presents:

Seed magnetic field generation in the cosmos



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Magnets have practically become everyday objects. Permanent ferromagnetism is a property of only a few densely packed materials, such as iron, in which the spin exchange interactions of individual atoms naturally line up in the same direction and create a residual persistent magnetic field. In the early universe, before iron and other magnetic materials had been created inside stars, such permanent magnetism did not exist. Scientists have long wondered where the observed cosmic magnetization came from, given that the fully ionized gas of the early universe contained no ferromagnetic particles.

Many astrophysicists believe that galactic magnetic fields are generated and maintained by dynamo action, whereby the energy associated with the differential rotation of spiral galaxies is converted into magnetic field energy. However, the dynamo mechanism is only a means of amplification, and dynamos require seed magnetic fields. Neither the dynamo process nor plasma instabilities generate magnetic fields out of nothing: they need finite seed fields to start from.

In the talk it is shown that an unmagnetized nonrelativistic thermal electron-proton plasma spontaneously emits aperiodic turbulent magnetic field fluctuations of strength $|\delta B|=3.5\beta _eg^{1/3}W_e^{1/2}$ G, where $\beta _e$ is the normalized thermal electron temperature, W_e the thermal plasma energy density and g the plasma parameter. For the unmagnetized intergalactic medium, immediately after the reionization onset, the field strengths from this mechanism are about $2\cdot 10^{-16}$ G in cosmic voids and $2\cdot 10^{-10}$ G in protogalaxies, both too weak to affect the dynamics of the plasma. Accounting for simultaneous viscous damping reduces these estimates to $2\cdot 10^{-21}$ G in cosmic voids and $2\cdot 10^{-12}$ G in protogalaxies. The shear and/or compression of the intergalactic and protogalactic medium exerted by the first supernova explosions locally amplify these seed fields and make them anisotropic, until the magnetic restoring forces affect the gas dynamics at ordered plasma betas near unity.

Friday, March 15, 2013
4:00-5:00P.M.
Olin Physical Sciences
Room 140