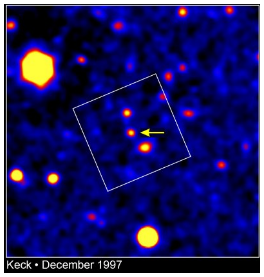
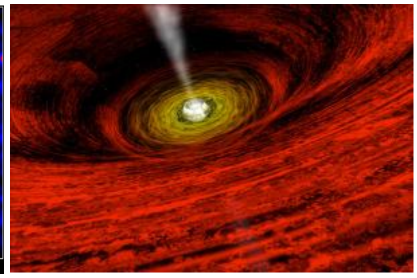
Compositions in Gamma-Ray Burst Jets



GRB 971214[1]



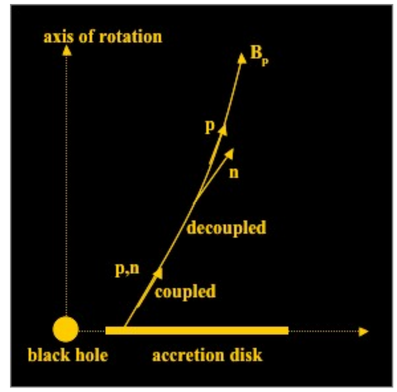
black hole - accretion disk - jet[2]

It is generally accepted that gamma-ray bursts (GRBs) are produced in relativistic jets formed out of an accretion disk/black hole system. Understanding the physics of jets is critical for extracting information on the mysterious central engine. An important quantity in the jets is the composition, which produces observable gamma-ray and neutrino emissions.

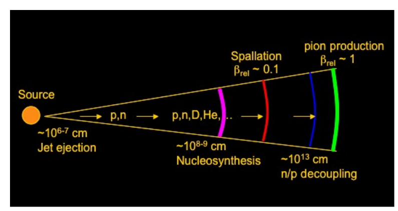
GRB outflows are expected to be neutron-rich, with neutron-to-proton ratios as high as $n/p \sim 20 - 30$. When the coupling timescale becomes comparable to the acceleration timescale, neutrons begin to decouple from protons. We (Vlahakis, Peng & Königl, 2003) proposed a two-component MHD jet model for which the neutron component is decoupled from the proton outflows at Lorentz factor $\sim$ 15. The high-energy ($\sim$ GeV) inelastic collisions among relativistic neutrons and protons may convert the extra neutrons into protons via pion production. However, spallation of light elements can also affect the n/p ratios. The neutron-to-proton ratio determines the energy allocation of jet components and affects the early and later afterglows. It is a controlling variable in the nucleosynthesis of the jet material. Considering all these physical processes that might change the neutron-to-proton ratios, we are investigating the following questions: Can high n/p ratios be sustained during and after the decoupling of neutrons and protons? What elements can be produced in the jets? What neutrino emission will result from the nuclear and dynamical processes accompanying jet propagation?

This work would be the first fully consistent study of early jet nucleosynthesis including the effects of magnetic fields.

Image credit: [1]Keck, [2]CXC/NASA/SAO. This work has been supported by NSF Grant PHY 02-16783 (Joint Institute for Nuclear Astrophysics). JWT acknowledges the support by the DOE, Office of Nuclear Physics, under Contract No. W-31-109-ENG-38.



Neutrons decouple from the proton component at a Lorentz Factor $\sim$ 15 in a magnetohydrodynamic jet model.



Schematic plot of the possible physical processes which can affect the composition during the jet propagation.

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