PARTICLE CASCADES IN SGR A*: THE POSSIBILITY OF OBSERVING THEIR γ-RAY SIGNATURE

SERA MARKOFF
Physics Department, The University of Arizona
FULVIO MELIA
Physics Department and Steward Observatory
The University of Arizona
AND
INA SARCEVIC
Physics Department, The University of Arizona

The recent detection of a γ-ray flux from the direction of the Galactic center by EGRET on the Compton GRO raises the question of whether this is a point source (possibly coincident with the massive black hole candidate Sgr A*) or a diffuse emitter. Using the latest experimental particle physics data and theoretical models, we have examined in detail the γ-ray spectrum produced by synchrotron, inverse Compton scattering and mesonic decay resulting from the interaction of relativistic protons with hydrogen accreting onto a point-like object. Such a distribution of high-energy baryons may be expected to form within an accretion shock as the inflowing gas becomes supersonic. This scenario is motivated by hydrodynamic studies of Bondi-Hoyle accretion onto Sgr A*, which indicate that many of its radiative characteristics may ultimately be associated with energy liberated as this plasma descends down into the deep potential well. Earlier attempts at analyzing this process concluded that the EGRET data are inconsistent with a massive point-like object (Mastichiadis & Ozernoy, 1994). Our results demonstrate that a more careful treatment of the physics of p-p scattering suggests that a $\sim 10^6\ M_\odot$ black hole may be contributing to this high-energy emission.

The accreting matter around Sgr A* can form a shock between $40 - 120\, r_g$ (Babul & Ostriker, 1988), which may accelerate a fraction of the particles (mostly ionized hydrogen) to very high energy. The relativistic protons are injected through the shock region with a rate $\dot{\rho}_p(E_p) = \rho_o E_p^{-x}$

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cm^{-3} s^{-1} GeV^{-1}, where the normalization ρ_o is related to the efficiency η of the shock. In steady state this leads to a power-law distribution of relativistic particles with index $z \sim 2.0 - 2.4$ (Jones & Ellison, 1991). These relativistic protons interact with the ambient particles and magnetic field, producing photons via synchrotron, inverse Compton scatterings and the decay of mesons created from collisions. The leading order nucleons produced also contribute via multiple collisions in an ensuing cascade. The steady state p distribution is determined via a diffusion loss treatment, and is used to calculate the p synchrotron and inverse Compton spectral components. Charged leptons created from decaying mesons can also be a source of radiation from synchrotron and inverse Compton processes, and we follow an analogous procedure to find their contributions to the spectrum. For details, see Markoff et al. (1997).

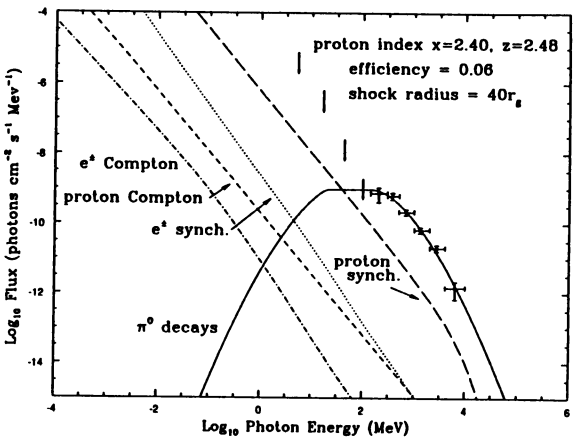

Figure 1. COMPTEL upper limits from Strong (1996), EGRET points from Mattox (1996).

Figure 1 shows the five spectral components for a shock at $40r_g$, with a proton index $x = 2.4$ and an efficiency of 6%. The data are best fit with the π^0 decay spectrum. It is also possible to fit the data with the proton synchrotron component, but the spectrum will miss the turnover in the lower EGRET energy bins.

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