Note on high-energy neutrinos from active galactic nuclei cores

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Taking account of new physics and astronomy developments I give a revised high-energy neutrino flux for the active galactic nuclei core model of Stecker, Done, Salamon and Sommers.

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In 1991 we proposed a model suggesting that very high-energy neutrinos could be produced in the cores of active galaxies (AGN) such as Seyfert galaxies [1]. Using that model, we gave estimates of the flux and spectrum of high-energy neutrinos to be expected (see [2]).

The fluxes given in Ref. [1] were normalized by assuming that 100% of the x-ray background was nonthermal radiation from a superposition of unresolved Seyfert galaxies. Subsequent observations of these AGN have shown that their emission is predominantly thermal and therefore cannot be directly related to the production of highly relativistic particles in such sources.

However, the extragalactic background radiation at MeV γ-ray energies may be due to nonthermal γ-ray emission from AGN. COMPTEL observations of the galactic black hole source Cyg X-1 show a hard tail of emission, extending out to MeV energies [3]. An explanation that has been suggested to account for this MeV tail is that the electron distribution is not completely thermalized [4]. This is physically reasonable since the thermalization time scales for the electrons can be smaller than the other time scales in these systems (e.g. Ref. [5]) The overall 2 keV to 5 MeV spectrum of Cyg X-1 can then be modeled if 90% of the power goes into a $\sim$100 keV thermal electron distribution, while the remaining $\sim$10% is in the form of a nonthermal γ-ray tail.

It is well known that the low-hard state spectra of Cyg X-1 and other galactic black hole sources bear a remarkable similarity to those from radio quiet AGN [6], with emission in both types of sources involving the same physical processes of disk accretion onto a black hole. Thus, we expect a similar hard tail to be present in the Seyfert galaxies. Observations of Seyfert galaxies having flat spectrum radio nuclei using the very long baseline array have shown that these sources are emitting nonthermal radiation from central core regions with sizes $\sim$0.05 to 0.2 pc [7]. Such cores may also be the source of both nonthermal MeV emission and high-energy neutrinos. A tail of the Cyg X-1 type could not be detected in an individual AGN using current instrumentation, but a superposition of such tails in the spectra of AGN could account for the reported MeV background spectrum and flux. Based on observations of Cyg X-1, and taking account of the fact that AGN contain much more massive black holes at their cores, one can assume that such sources exhibit a high-energy tail of roughly the same magnitude relative to the thermal emission as Cygnus X-1. A superposition of thermal emission from unresolved Seyferts with spectra in the x-ray range similar to Cyg X-1 can reasonably account for the x-ray background [8]. A superposition of such AGN spectra with Cyg X-1 type tails can also account for the shape and flux level of the MeV background [9].

In accord with the above arguments, if we assume that the extragalactic MeV background is made up of the 10% component of nonthermal radiation from Seyferts, this lowers the estimated AGN core ν_μ flux to an order of magnitude below that previously obtained by normalizing to the x-ray background in Ref. [1]. A further reduction in the ν_μ flux by a factor of 2 comes from neutrino oscillations, whose discovery was made after the publication of Ref. [1]. The new estimate is therefore obtained by lowering the flux shown in the figure in the erratum of Ref. [1] by a factor of 20. This rescaling gives a value for the ν_μ flux at 100 TeV of $E_\nu^2 \Phi(E_\nu) \sim 10^{-8}$ GeV cm^{-2} s^{-1} sr^{-1}. Such a flux is consistent with present limits from AMANDA [10].

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