Astrophys Space Sci
DOI 10.1007/s10509-013-1672-2

ORIGINAL ARTICLE

Ultra-high energy neutrino fluxes from supermassive AGN black holes

G. Ter-Kazarian

Received: 29 July 2013 / Accepted: 18 October 2013

Abstract We compute the ultra-high energy (UHE) neutrino fluxes from plausible accreting supermassive black holes closely linking to the 377 active galactic nuclei (AGNs). They have well-determined black hole masses collected from the literature. The neutrinos are produced via simple or modified URCA processes, even after the neutrino trapping, in superdense proto-matter medium. The resulting fluxes are ranging from: (1) (quark reactions)—$J^q_{\nu\varepsilon}/(\varepsilon_d\ \mathrm{erg\,cm^{-2}\,s^{-1}\,sr^{-1}}) \simeq 8.29\times10^{-16}$ to 3.18×10^{-4}, with the average $\overline{J}^q_{\nu\varepsilon} \simeq 5.53\times10^{-10}\varepsilon_d\ \mathrm{erg\,cm^{-2}\,s^{-1}\,sr^{-1}}$, where $\varepsilon_d \sim 10^{-12}$ is the opening parameter; (2) (pionic reactions)—$J^\pi_{\nu\varepsilon} \simeq 0.112 J^q_{\nu\varepsilon}$, with the average $J^\pi_{\nu\varepsilon} \simeq 3.66\times10^{-11}\varepsilon_d\ \mathrm{erg\,cm^{-2}\,s^{-1}\,sr^{-1}}$; and (3) (modified URCA processes)—$J^{URCA}_{\nu\varepsilon} \simeq 7.39\times10^{-11} J^q_{\nu\varepsilon}$, with the average $\overline{J}^{URCA}_{\nu\varepsilon} \simeq 2.41\times10^{-20}\varepsilon_d\ \mathrm{erg\,cm^{-2}\,s^{-1}\,sr^{-1}}$. We conclude that the AGNs are favored as promising pure neutrino sources, because the computed neutrino fluxes are highly beamed along the plane of accretion disk, peaked at high energies and collimated in smaller opening angle $\theta \sim \varepsilon_d$.

Keywords Galaxies · Black holes · Neutrinos · Cosmic rays

1 Introduction

The extragalactic ZeV neutrinos may reveal clues on the puzzle of origin of ultra-high energy cosmic ray (UHECR) particles with huge energies exceeding 1.0×10^{20} eV (Linsley 1963). Cosmic ray particles with even higher energies have since been observed, (comprehensive reviews can be found in (Castellina and Donato 2013; Letessier-Selvon and Stanev 2011; Sigl 2011; Kotera and Olinto 2011; Semikoz 2010). The recent confirmation (Abbasi et al. 2008; Abraham et al. 2008) of the GZK suppression (Greisen 1966; Zatsepin and Kuzmin 1966a, 1966b) in the cosmic ray energy spectrum indicates that the cosmic rays with energies above the GZK cutoff, $E_{GZK} \sim 40$ EeV, mostly come from relatively close (within the GZK radius, $r_{GZK} \sim 100$ Mpc) extragalactic sources. But, the identification of their sources is still an open question. Neutrinos can penetrate cosmological distances and their trajectories are not deflected by magnetic fields as they are neutral. By virtue of these properties, they open a new window onto Universe in ways which no other particle can. Therefore, an appealing possibility among the various hypotheses of the origin of UHECR is the so-called Z-burst scenario (Weiler 1982, 1984, 1999; Fargion et al. 1999; Fargion and Colaiuda 2004; Datta et al. 2005; Yoshida et al. 1998; Ringwald 2001; Fodor et al. 2002; Kalashev et al. 2002a, 2002b; Neronov and Semikoz 2002; Jain and Panda 2005). This suggests that if ZeV astrophysical neutrino beam is sufficiently strong it can produce a large fraction of observed UHECR within 100 Mpc by hitting local light relic neutrinos clustered in dark halos and form UHECR through the hadronic Z (s-channel production) and W-bosons (t-channel production) decays by weak interactions. The discovery of UHE neutrino sources would also clarify the production mechanism of the GeV-TeV gamma-rays observed on Earth (Gaisser et al. 1995; Alvarez-Muñiz and Halzen 2002; Fargion and Colaiuda 2004). The weakest link in the Z-burst hypothesis are probably both unknown boosting mechanism of the primary neutrinos up to huge energies of hundreds ZeV and their large flux required at the resonant energy $E_\nu \simeq M_Z^2/(2m_\nu) \simeq 4.2\times10^{21}$ eV (eV/m_ν)

G. Ter-Kazarian (✉)
Byurakan Astrophysical Observatory, Byurakan 378433, Aragatsotn District, Armenia
e-mail: gago_50@yahoo.com

Published online: 09 November 2013