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Galactic discrete sources of high energy neutrinos

W. Bednarek [a], G.F. Burgio [b,*], T. Montaruli [c]

[a] *Department of Experimental Physics, University of Łódź, ul. Pomorska 149/153, 90-236 Łódź, Poland*
[b] *INFN Sezione di Catania, Via S. Sofia 64, I-95123 Catania, Italy*
[c] *Dipartimento di Fisica and INFN Sezione di Bari, Via Amendola 173, I-70126 Bari, Italy*

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Abstract

We review recently developed models of galactic discrete sources of high energy neutrinos. Some of them are based on a simple rescaling of the TeV γ-ray fluxes from recently detected galactic sources, such as, shell-type supernova remnants or pulsar wind nebulae. Others present detailed and originally performed modeling of processes occurring close to compact objects, i.e., neutron stars and low mass black holes, which are supposed to accelerate hadrons close to dense matter and radiation fields. Most of the models considered in this review optimistically assume that the energy content in relativistic hadrons is equal to a significant part of the maximum observable power output in specific sources, i.e., typically $\sim$10%. This may give a large overestimation of the neutrino fluxes. This is the case of models which postulate neutrino production in hadron–photon collisions already at the acceleration place, due to the likely $e^{\pm}$ pair plasma domination. Models postulating neutrino production in hadron–hadron collisions avoid such problems and therefore seem to be more promising. The neutrino telescopes currently taking data have not detected any excess from discrete sources yet, although some models could already be constrained by the limits they are providing.

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Contents

* Corresponding author. Tel.: +39 095 378 5317; fax: +39 095 378 5231.
E-mail address: fiorella.burgio@ct.infn.it (G.F. Burgio).

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1. Introduction

Galactic sources can potentially produce interesting event rates in neutrino telescopes. Since they are at shorter distances to the Earth ($\sim 1 \div 10$ kpc) compared to extra-galactic sources, the source luminosity required for a galactic source to produce the same event rate as an extra-galactic one, is orders of magnitude smaller (see Section 2). Given the large photon luminosities observed from some of the sources, it is possible to single out interesting candidate neutrino emitters in the Galaxy. A rough estimate of the source luminosity required to produce a certain event rate in a neutrino telescope (Halzen, 2003) is shown in Section 2.

In order to produce high energy neutrino fluxes, galactic sources must accelerate particles at sufficiently high energies. Hillas derived the maximum energy E at which a particle of charge Z can be accelerated, from the simple argument that the Larmor radius of the particle should be smaller than the size of the acceleration region (Hillas, 1984). If energy losses inside sources are neglected, this maximum energy E (in units of 10^{18} eV) is related to the strength of the magnetic field B (in units of μGauss) and the size of the accelerating region R (in units of kpc) by the following relationship:

$$E_{18} \sim \beta Z B_{\mu G} R_{\mathrm{kpc}}, \qquad (1)$$

where β is the velocity of the shock wave or the acceleration mechanism efficiency. Hence, the maximum energy up to which particles can be accelerated depends on the BR product. Particle acceleration may occur in many candidate sites, with sizes ranging from kilometers to megaparsecs.