Journal of Astrophysics & Aerospace Technology

Chang, J Astrophys Aerospace Technol 2012, 1:1
DOI: 10.4172/1218,5431.1000e102

Editorial Open Access

Symmetry Already Broken, but Answer Still Elusive - the Galactic 511 keV Emission

Hsiang-Kuang Chang*

Institute of Astronomy, National Tsing Hua University, Taiwan

It has been 40 years since the galactic 511-keV line emission was discovered [1]. That emission mainly comes from the direction of our galactic center with a seemingly spherically symmetric spatial distribution. Despite of intensive investigation in both observation and theory in the last four decades, the reason why our galactic center hosts such an electron-positron annihilation emission activity remains unclear. What is the source of those positrons?

Various sources have been proposed in the literature. Some of them are related to the β^+-decay of radioactive nuclei produced in nucleosynthesis processes in stellar environments, such as novae, supernovae (including SNIa), hyper novae (the hypothesized event for long gamma-ray bursts) or massive stars. Some of them are related to high-energy processes such as proton-proton collisions, two photon pair production and one-photon pair production. They happen in the interstellar medium for cosmic rays, in the magnetosphere of pulsars (including millisecond pulsars), in the inner accretion disk and/or jets of X-ray binaries and micro-quasars, and in the vicinity of the super massive black hole sitting at the center of our galaxy. Most of the above sources suffer from the issue of only being able to produce a low buldge-to-disk luminosity ratio, rather than the observed high ratio of 5 or so. To solve this puzzle, models of hypothetical dark matter annihilation and de-excitation as the positron source were suggested. A comprehensive review on this subject can be found in [2]. Although dark matter models have huge uncertainty in their intrinsic properties and their very existence, it would be exciting if later the galactic 511 keV emission could be firmly proved to be the signature of dark matter non-gravitational interactions.

One observational breakthrough was published 4 years ago [3] reporting an asymmetric disk component in the inner disk region ($|\ell| < 50°$). Based on that asymmetric distribution, authors of that paper suggested that hard Low-Mass X-ray Binaries (LMXBs) be the source of required positrons and, adding other astrophysical sources, 'there may be no necessity to invoke exotic explanations such as the annihilate of dark matter'. One of the major arguments with which [3] could reach their suggestion is that the asymmetry is neither due to observational bias nor to the difference in the interstellar environments. Furthermore, it was argued that positrons leaving those hard LMXBs will annihilation soon, typically within 10^5 years and within 100 pc. However, the spectral line profiles reported in the same paper in fact indicate possible difference in the interstellar environments of positive and negative galactic longitude regions. One can see that the ratio of line strength to the positronium continuum is larger in the region of $-50° < \ell < 0°$; see Figure 3 in [3]. It indicates possible difference in the environments for pair annihilation and possible significance of the positron propagation. It therefore may not be solid yet to give hard LMXBs a special credit for providing the required positrons.

Propagation will be an important issue when the produced positrons have high energy. Annihilation mainly happens when electrons and positrons are cooled down to thermal states. In such a case, annihilation emission distribution does not map the source distribution directly. How positrons cool down and propagate in the interstellar space depends on the interstellar environments, in particular the interstellar turbulent magnetic fields. It is by itself a complicated issue. The local interstellar environments will also affect the annihilation rate, and therefore further modify the mapping between the spatial distribution of annihilation emission and positron sources. Despite of all these complexities and the discovery of an asymmetric disk component, since astrophysical sources cannot satisfyingly account for the observation, spherically symmetric dark matter annihilation and de-excitation models have been further developed, e.g. in [4]. It is likely that various sources together are responsible for what we observed. One important issue is whether there is room for dark matter to play. In any case, instruments with higher resolution and sensitivity are required for the next breakthrough. In this regard, I would like to draw readers' attention to the Nuclear Compton Telescope (NCT) project [5,6], which is exactly such an effort to develop the next generation Compton telescope with high sensitivity. Let's wait for new observations to bring us new insight.

References

1. Johnson WN, Harnden FR, Haymes RC (1972) The Spectrum of Low-Energy Gamma Radiation from the Galactic-Center Region. Astrophys J 172: L1-L7.
2. Prantzos N, Boehm C, Bykov AM, Diehl R, Ferriere K, et al. (2011) The 511 keV emission from positron annihilation in the Galaxy. Rev Mod Phy 83: 1001-1056.
3. Weidenspointner G, Skinner G, Jean P, Knödlseder J, von Ballmoos P, et al. (2008) An asymmetric distribution of positrons in the Galactic disk revealed by gamma-rays. Nature 451: 159-162.
4. Vincent AC, Martin P, Cline JM (2012) Interacting dark matter contribution to the galactic 511 keV gamma ray emission: constraining the morphology with INTEGRAL/SPI observations. JCAP 022.
5. Chang HK, Boggs S, Chang YH (2007) The Nuclear Compton Telescope (NCT): Scientific goals and expected sensitivity. ASR 40: 1281-1287.
6. Bandstra MS, Bellm EC, Boggs SE, Perez-Becker D, Zoglauer A, et al. (2011) Detection and Imaging of the Crab Nebula with the Nuclear Compton Telescope. Astrophys J 738: 8.

***Corresponding author:** Hsiang-Kuang Chang, Professor, Institute of Astronomy, National Tsing Hua University, Taiwan, Tel: 886-3-5742952; Fax: 886-3-5723052, E-mail: hkchang@phys.nthu.edu.tw

Received May 18, 2011; **Accepted** May 19, 2011; **Published** May 22, 2012

Citation: Chang HK (2012) Symmetry Already Broken, but Answer Still Elusive -the Galactic 511 keV Emission. J Astrophys Aerospace Technol 1:e102. doi:10.4172/2329-6542.1000e102