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The TeV gamma-ray source population of the Milky-Way

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1. SUMMARY

Recently the H.E.S.S. observatory has completed the first systematic survey of the Galactic plane in the very high-energy domain. Remarkably, the astrophysical nature of the majority of detected sources is still unknown. In this work, we present a novel analysis of the flux, longitude and latitude distributions of the brightest sources ($\Phi \geq 10\%\,\Phi_{\rm CRAB} = 0.1 \times 2.26 \times 10^{-11}\,{\rm cm}^{-2}\,{\rm s}^{-1}$) of the HGPS catalogue showing that the luminosity distribution of Galactic TeV sources can be effectively constrained.

More precisely, by assuming that the source space distribution follow the one of PWN as in Lorimer et Al (2006) and that the luminosity one is described by a power-law, we extract the source maximal luminosity $L_{\rm max} = 4.9^{+3.0}_{-2.1} \times 10^{35}\,{\rm ergs\,s^{-1}}$ and the high-luminosity normalization of the source distribution $\mathcal{N} = 17^{+14}_{-6}$ (the spin-down timescale $\tau_{\rm sd} = 1.8^{+1.5}_{-0.6} \times 10^{3}\,{\rm yr}$) by fitting HPGS data. This allow us to determine the total Milky Way luminosity $L_{\rm MW} = 1.7^{+0.5}_{-0.4} \times 10^{37}{\rm ergs\,s^{-1}}$ in the energy range $1 - 100\,{\rm TeV}$ and the total Galactic flux $\Phi_{\rm tot} = 3.8^{+1.0}_{-1.0} \times 10^{-10}{\rm cm}^{-2}\,{\rm s}^{-1}$ due to both resolved and unresolved sources in the H.E.S.S. observational window and in the same energy range. The total source flux is relatively large, implying that unresolved source contribution is not negligible and responsible for a large fraction of the diffuse large-scale gamma-ray signal observed by H.E.S.S. being about 60% (38%) of the resolved one (of the total flux $\Phi_{\rm tot}$). This could have important implications for the interpretation of current observations of other experiments in the TeV domain. Our results can also be used to investigate the capability of future detectors, like e.g. CTA, to probe the Galactic TeV source population.

Moreover, we consider the possibility that the bright sources observed by H.E.S.S., which are not firmly identified as SNRs, are powered by pulsar activity, like e.g. PWNe and/or TeV halos and we evaluate the constraints on the pulsar properties, namely the initial spin-down period and the neutron star magnetic field, that follow from this hypothesis. For our reference case, assuming that the fraction of the pulsar spin-down energy converted in TeV photons is $\lambda = 10^{-3}$, we obtain the best-fit values for the initial period $P_0 = 33.5^{+5.4}_{-4.3}\,{\rm ms}$ and the magnetic field $B_0 = 4.3\,(1 \pm 0.45) \times 10^{12}\,{\rm G}$. The above constraints are consistent with the B_0 value obtained in Faucher-Giguere et Al (2005) from pulsar radio observation and P_0 constrains described in Watters et Al (2010) by studying the gamma-ray pulsar population. Finally, by considering that 10 sources in HPGS catalouge have been firmly identified as PWNe and considering $\lambda \leq 5 \times 10^{-2}$ as an upper bound for efficiency of TeV emission, we obtain that the intial spin-down period of the considered pulsar population is constrained to be $P_0 \leq 500\,{\rm ms}$.