



Search for very high energy gamma-ray emission with H.E.S.S. from the young and massive stellar cluster Westerlund 1

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Abstract: Westerlund 1 is a unique case of a massive young cluster with at least 26 Wolf-Rayet stars driving strong stellar winds. It is possible that various configurations of these stellar winds (wind-wind interaction, superposition of stellar winds etc.) can convert a fraction of the kinetic energy of the wind into accelerated particles. Observations of spatially extended non-thermal X-ray emission from the highly reddened cluster Westerlund 1 suggest that indeed stars are able to accelerate at least electrons to TeV energies which then produce X-ray synchrotron emission. We report on the results of H.E.S.S. observations of the Westerlund 1 cluster.

Introduction

Westerlund 1 (Wd 1) is a young ($t \approx 5$ Myrs) massive ($M \approx 6 \times 10^4 M_{\odot}$) stellar cluster at an estimated distance of (3.9 ± 0.7) kpc [7] located in the Scutum-Crux arm. The most massive stars in Wd 1 have already evolved to form supernovae which can be concluded from the presence of a $P = 10.4$ s magnetar with a massive progenitor ($M > 40 M_{\odot}$) associated with the cluster [8, 10]. Wd 1 is a unique case of a stellar association containing a large number of high metallicity Wolf-Rayet (W-R) stars. The lower limit of known W-R stars present in Wd 1 is 26 [2, 11] which is a substantial fraction of all known Galactic W-R stars. The binary fraction of the W-R stars is estimated to be 60-70 % [3].

The total power injected into the intracluster medium in the form of kinetic energy of the fast winds is estimated to be 10^{39} ergs/s. Given the fact that the most massive stars of Wd 1 have already produced supernovae, the average injected luminosity over the last million year is roughly $(1 - 3) \times 10^{39}$ ergs/s (assuming a supernova rate of 10^{-4} yr⁻¹, comparable to the power released

in the stellar winds. No shell has been detected which is expected if the cluster gas is dilute ($n < 0.6$ cm⁻³). The evolution of supernova remnants in stellar clusters is predicted to be different from the one of isolated supernova remnants (see e.g. [12])

While some of the available kinetic energy $E_{\text{kin}} > 10^{52}$ ergs has been converted into an expanding superbubble formed around Wd 1 [7], the bulk of the energy remains undetected. X-ray observations have revealed the presence of diffuse non-thermal X-ray emission with a total power of $L_X \approx 3 \times 10^{34}$ ergs/s [9]. The characteristics of the observed X-ray emission (extension and hard spectrum) are not typical for a cluster with these parameters and remain largely unexplained.

Gamma-ray observations of Wd 1 can provide an important constraint on the efficiency in which the kinetic energy of the winds and the supernova remnants have been converted into acceleration of a non-thermal particle population. The large solid angle covered with the H.E.S.S. telescopes allows to probe the total energetics of this particle population that is difficult to detect in other wavelengths if the accelerated particles are mainly nuclei. Cos-

mic ray acceleration in the environments of stellar clusters has been suggested in the past to be of relevance for the total Galactic cosmic ray budget as the abundance ratio of $^{22}\text{Ne}/^{20}\text{Ne}$ is roughly five times solar and indicates that parts of the cosmic rays have been very likely accelerated in high metallicity environments like OB associations containing W-R stars where also most ($\simeq 75\%$) of Galactic supernovae occur [5, 6].

Gamma-ray emission has been associated with OB associations in the past including Wd-2 [4] and Cyg OB2 [1].

Observations

Observations with the HESS array of imaging air Cherenkov telescopes will be reported at the conference.

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