# Multi-wavelength properties of pulsar wind nebulae: Evolutionary constraints from H.E.S.S. observations

O.C. de Jager[1], Anne Lemiére[2], and A. Djannati-Ata
"i[2] for the H.E.S.S. Collaboration

[1]Unit for Space Physics, North-West University, Potchefstroom 2520, South Africa
[2]Astroparticle Group, APC College de France, 11, Place Marcelin Berthelot, 75231 Paris Cedex 05, France

**ABSTRACT:** Apart from giving a general review of the multi-wavelength properties of pulsar wind nebulae (PWN), we also concentrate on the new spectral window at very high energy (VHE) gamma-rays opened for PWN studies: The superb angular resolution at very high gamma-ray energies offered by ground based imaging atmospheric Cherenkov telescopes allow us to resolve the extended emission of a number of pulsar wind nebulae: The High Energy Stereoscopic System (H.E.S.S.) in Namibia, Southern Africa, resolved for the first time PWN at gamma-ray energies, which forces us to go beyond simple phenomological models. Furthermore, such observations also give us a direct probe of the ultra-relativistic particle component accelerated by the pulsar wind. If we interpret this resolved component as inverse Compton scattering by ultra relativistic electrons on the CMBR, it can be shown that the associated field strengths are of the order of $10\mu$G or less for the HESS sources considered. The corresponding synchrotron emission of this same electron component would then contribute mostly to the unseen extreme ultraviolet to soft X-ray band. Thus, by ordering multi-wavelength observations in the sequence of radio, VHE gamma-ray and X-ray observations, we effectively probe a decreasing sequence of electron lifetimes. We will then show how multi-wavelength messengers (radio through VHE gamma-rays) can be used to constrain MHD models for pulsar wind transport, as well as time dependent models of PWN expansion and pulsar spindown. We will consider VHE gamma-ray PWN such as HESS J1825-137 (or G18.0-0.7), G0.9+0.1, the wind nebula of PSR B1509-58, and Vela X. For the latter source we will also compare a hadronic versus leptonic interpretation and comment on constraints on such models. We also need to understand why the PWN of PSR B1706-44 and G21.5-0.9 were not detected at VHE energies. New HESS results approved at the time of the meeting will also be discussed, and we will show why future northern hemisphere VHE observations of 3C58 are important. The discovery of "dark sources" (such as HESS 1303-631) as possible PWN from spun-down middle aged pulsars will also be discussed, and for such cases we will derive the maximal expected ratio (or "apparent efficiency") of gamma-ray luminosity to current spindown power. Such numbers are important to understand the PWN candidates in the newly discovered population of galactic plane sources revealed by HESS.