Multiwavelength spectrum of the HESS J1818-154/G15.4+0.1 system

A. D. Supanitsky, G. Castelletti, and L. Supan

Instituto de Astronomía y Física del Espacio, (IAFE, CONICET - UBA)

Motivation

Since its discovery, the TeV source HESS J1818-154 has been linked to the supernova remnant (SNR) G15.4+0.1 [1]. Both inverse Compton (IC) mechanism and neutral pion decay of accelerated protons were used to explain the observed TeV gamma-ray flux. The former was invoked since the detection of diffuse X-ray emission from a region compatible with the extended HESS source [2], while the discovery of dense molecular clouds interacting with the SNR was considered an argument to favor a hadronic scenario [3]. We present the updated broad-band spectral energy distribution (SED) of G15.4+0.1 including new radio data from the GMRT and VLA interferometers, X-ray observations from *XMM-Newton*, and gamma-ray fluxes from H.E.S.S. We also used hadronic and leptonic-only models to explore the contributions that the proposed mechanisms makes to the overall spectrum of G15.4+0.1.

Observations

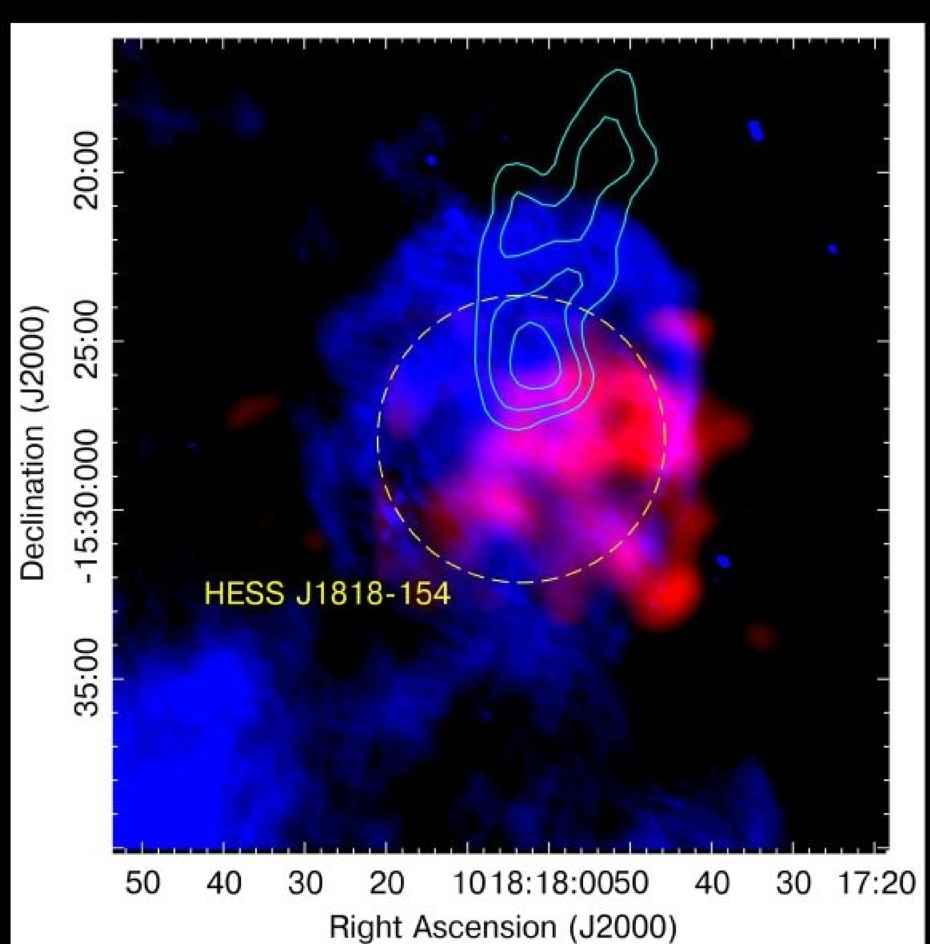
Radio observations of the SNR G15.4+0.1 were carried out at 610 and 1420 MHz using the interferometer Giant Metrewave Radio Telescope (GMRT, India). The data were obtained on May 10 and 11, 2012 (project ID: 22-015). We used the NRAO Astronomical Image Processing System (AIPS) software package to fully reduce and image the observations. The resulting images have a synthesized beam of 3".5 x 3".0 and 7".0 x 4".6 and an rms noise level of 0.1 and 0.15 mJy beam^{-1} at 610 and 1420 MHz, respectively [3,4].

We also reprocessed X-ray data from the *XMM-Newton* archive (Obs. ID: 0691390101, date 10/10/12) following the standard processing chain to obtain clean events files for both MOS1 and MOS2 cameras. After an appropriate filtering, the resulting net exposure time was 30 ks.

HESS J1818-154
size: ~8'.5
F (> 1TeV) = 4.0 x 10^{-13} cm^{-2} s^{-1}

SNR G15.4+0.1
size: ~14' x 10'

Integrated radio flux densities:
$S_{610\,MHz} = 8.0 \pm 1.1$ Jy
$S_{1420\,MHz} = 4.7 \pm 0.2$ Jy



A color composite image showing the spatial correlation between the synchrotron radio emission at 610 MHz of SNR G15.4+0.1 (in blue) and the X-ray emission as observed by *XMM-Newton* (in red). The radio image was smoothed to an angular resolution of 10''. The cyan contours delineate the molecular cloud interacting with the SNR shock [3] while the dashed circle indicates the location and size of the HESS J1818-154 source [1].

Modeling the broad-band spectrum of the HESS J1818-154 / G15.4+0.1 system

Pros & Cons for Hadronic and Leptonic models

PRO hadronic

- **Dense molecular material** interacting with the northern and center parts of the SNR shell (Mass ~1200 $M_\odot$, n ~ 1500 cm^{-3}) [3].
- **Energetic arguments**: a conversion factor of only a few percent of the SN explosion energy into relativistic protons is needed to account for a hadronic origin of the γ-rays in HESS J1818-154 [3].

PRO leptonic

- **Spatial coincidence** between X-rays and gamma-rays [2].

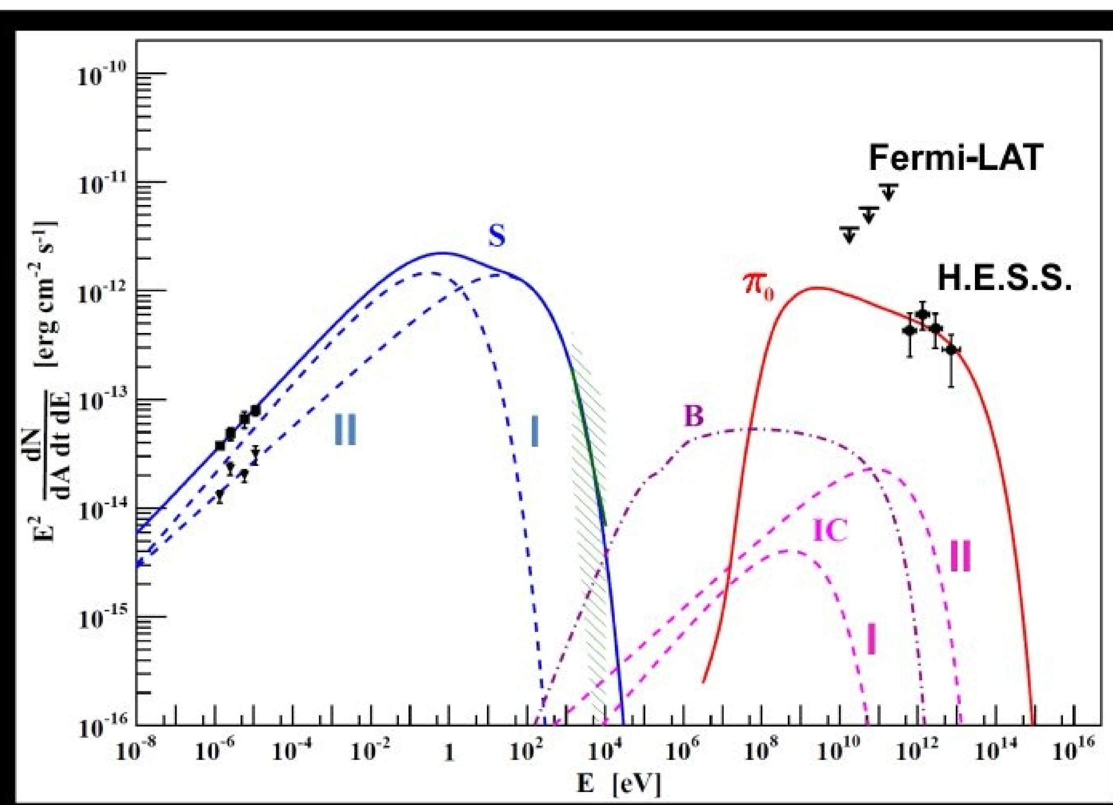
CON leptonic

- **A PWN in X-rays?** *XMM-Newton* data are well fitted using both thermal and non-thermal models [2].
- **A pulsar associated with G15.4+0.1?** No pulsations detected in either radio or X-rays [4,2].

From data to models: Hadronic vs. Leptonic

Hadronic model

Processes		Injection spectra
S: Synchrotron radiation [5]	IC: Inverse Compton [6]	$\phi(E) = KE^{-\gamma}\exp(-E/E_{cut})$
B: Bremsstrahlung [7]	π_0: Neutral pion decay [8]	For both protons and electrons



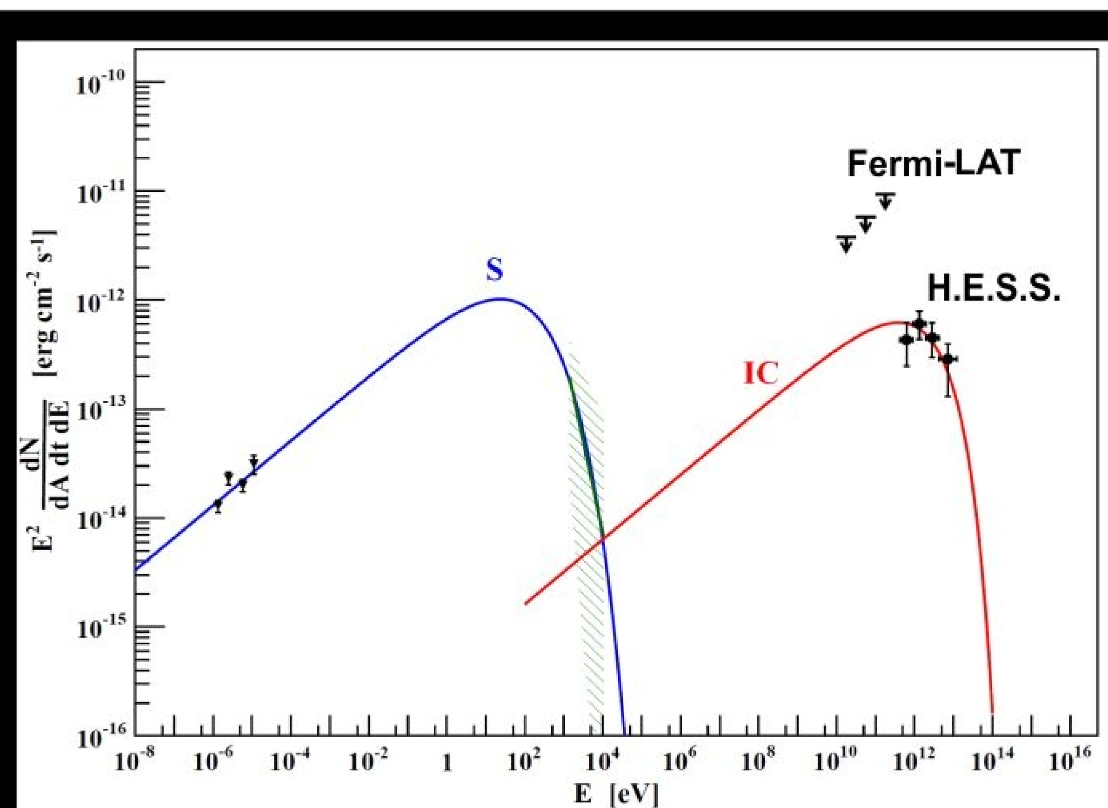
Fit to the SED obtained for a hadronic scenario. The dashed curves labeled **I** and **II** refer to the emission from the whole remnant and the internal SNR region, respectively. It is assumed that the Bremsstrahlung of the internal region is negligible. The radio data at 330 and 2700 MHz are from VLA and Effelsberg observations [9], while the 610 and 1420 MHz points are from GMRT data [4]. The green region corresponds to the X-ray energy band [2].

Parameters of the model

	Leptons			Protons	
Region	B [μG]	γ	E_{cut} [eV]	γ	E_{cut} [eV]
Internal	25	2.35 ± 0.14	$10^{12.83}$	2.41	$10^{14.6 \pm 0.5}$
Remnant	62.5	2.16 ± 0.08	$10^{11.6}$		

Leptonic model

Processes		Injection spectra
S: Synchrotron radiation [5]	IC: Inverse Compton [6]	$\phi(E) = KE^{-\gamma}\exp(-E/E_{cut})$



Fit to SED in a leptonic scenario in which the gamma-rays are produced by CMB photons inverse Compton scattered by relativistic electrons from the internal region of SNR G15.4+0.1.

Parameters of the model

B [μG]	γ	E_{cut} [eV]
3.9 ± 1.4	2.41 ± 0.09	$10^{13.303 \pm 0.071}$

Conclusions

Based on the existing data, we have demonstrated that the broad-band spectrum for the HESS J1818-154/G15.4+0.1 system is compatible with a hadronic model to explain the origin of the gamma-rays. Additional data in the 50-200 MeV energy band, where the hadronic and leptonic components are expected to show different behaviors, are needed to confirm this scenario.

References

[1] Hofverberg et al. 2011, 32rd ICRC, 7, 247
[2] Abramowski et al. 2014, A&A, 562, A40
[3] Castelletti et al. 2013, A&A, 557, L15
[4] Supan et al. 2014, in preparation
[5] Crusius et al. 1986, A& A, 164, L16
[6] Jones 1968, Phys. Rev., 167, 1159
[7] Baring et al. 1999, ApJ, 513, 311
[8] Kachelriess & Ostapchenko 2012, Phys. Rev., D86, 043004
[9] Brogan et al. 2006, ApJ, 639, L25

A. D. Supanitsky: supanitsky@iafe.uba.ar