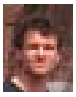
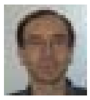


Mapping the TeV SNR RX J1713.7-3946



Acero, F.; Ballet, J.

DSM/IRFU/Service d'Astrophysique, UMR 7158, CEA Saclay, Email : facero@cea.fr, jballet@cea.fr

Cassam-Chenai, G.; Decourchelle, A.; Degrange, B.; Lemoine-Goumard, M.

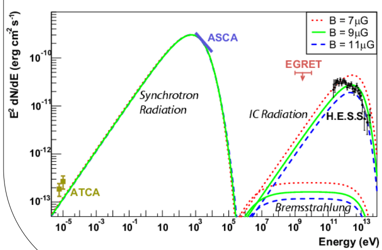
Abstract : The supernova remnant (SNR) RX J1713.7-3946 is one of the few shell-type SNRs observed at TeV energies. The comparison of the SNR in X-rays and in gamma-rays can help us improve our understanding the nature of the underlying emission mechanisms. Spatially resolved spectral studies done earlier in X- and gamma-rays (respectively with the XMM-Newton and the HESS telescopes) revealed an intrinsic scatter on photon index in X-rays but not in gamma-rays. However both studies did not use the same extraction regions. Using recent observations (Fall 2007) that complete the previous mosaic of the remnant, we present the first full coverage of RX J1713.7-3946 with XMM-Newton. We compared the spectra and radial profiles obtained at TeV energies and in X-rays using the same extraction regions and spatial resolution as in the gamma-ray study. We found no remaining variations of the photon index in the X-ray data. The correlation between the X and gamma-ray fluxes is steeper than linear. The gamma-rays appear to extend further out than the X-rays.

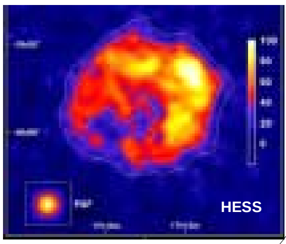
RX J1713.7-3946

- 1 degree diameter remnant close to Galactic plane (G347.3-0.5).
- Average absorbing column (from X-rays) 5 to 6 10^{21} cm^{-2}.
- Likely distance is 1 to 1.5 kpc (association with clouds in the West and absorption value). Radius is then 8 to 13 pc.
- Might be remnant of SN 393 (1600 years old).
- Central compact object is present, therefore SN II. Possibly exploded in wind-blown shell recently reached by the shock.
- No thermal emission detected. Most likely reason is that the ambient density is low (< 0.02 cm^{-3}). Consistent with the size for reasonable energy (10^{51} erg).
- X-rays (excluding point sources) are synchrotron, due to electrons accelerated at TeV energies. On small scales, spectral slope is variable and positively correlated with flux and N_H (ie the brighter the softer and more absorbed).
- Emission is filamentary (probably sheets in projection). If width (40" or 0.25 pc) is interpreted as cooling length, implies post-shock B around 80 μG.

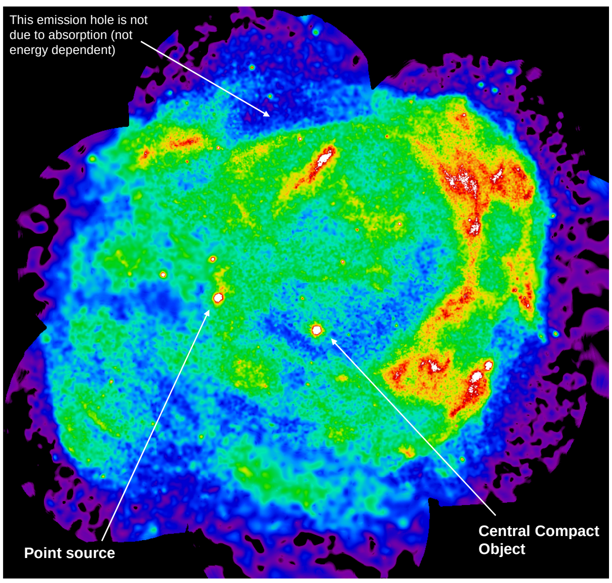
Prototype TeV supernova remnant

RX J1713.7-3946 was the first extended source mapped at TeV energies. It is the TeV SNR best measured at all wavelengths (radio is not perfect, unfortunately, due to a lot of confusion), and the best hope to model the non thermal broad band spectrum of an SNR. The leptonic model below (Aharonian et al. 06) assumes low density (consistent with no thermal X-rays) and Inverse Compton TeV emission. It is fine except it requires a small B to explain the large TeV/X ratio. Models explaining TeV emission by hadronic interactions (accelerated protons on thermal gas), on the other hand, need larger density and predict too many thermal X-rays.



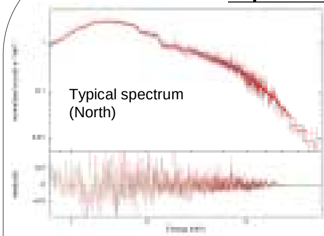


X-ray mosaic

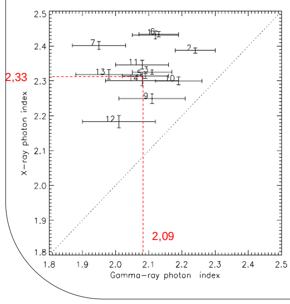


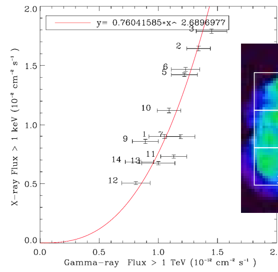
New full X-ray map: 8 XMM-Newton pointings (south was full of flares and will be redone this year). MOS + PN summed, 0.5 to 5 keV. The squares are areas over which the TeV spectrum was extracted by Aharonian et al 06.

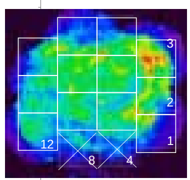
Spectral comparison



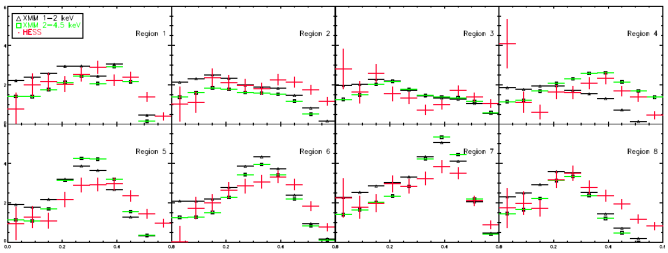
- Exposure corrected MOS 1+2, convolved with HESS PSF. Spectrum extracted in HESS square boxes shown on map
- X-ray flux / slope correlation seen at small scale is washed out
- Average X-ray slope slightly softer than TeV.
- X-ray flux increases faster than TeV.



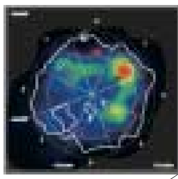




Morphological comparison



- Same data as above. Radial profile extracted in angular sectors shown at right
- X-rays more peaked in shell (5, 6, 7) than TeV. Probably same effect as above (more contrast in X-rays)
- X-rays do not extend as far as TeV (5, 6, 8)
- Central enhancement in X-rays below 2 keV



Discussion

- In a leptonic scenario, the steeper X-ray index (compared to TeV) implies that the radiating electrons are at slightly larger energy for X-rays. OK as long as B < 100 μG.
- If due to varying ambient density, the larger contrast in X-rays than TeV can be explained in leptonic model if B increases with n. It is more difficult to explain in a hadronic model which predicts a fast TeV increase with n as well (as n_{cr} n_{gas}).
- A leptonic model can be reconciled with the X-ray filaments if the magnetic turbulence decays behind the shock. This predicts broader TeV emission (OK) but on average inside X-ray emission (CMB and IR photons are uniform, 10 - 20 TeV electrons do not diffuse far ahead of the shock), contrary to what is observed.
- In a hadronic model, the TeV emission outside X-rays could be due to diffusion into the neighboring dense clouds. This should go further at high energy.

Conclusion

- ✓ **We have assembled a full X-ray map of the RX J1713.7-3946 SNR at the spatial resolution of XMM-Newton**
- ✓ **The flux contrast between the bright and faint areas is larger than at TeV energies**
- ✓ **The X-ray emission (at the same resolution as the TeV) does not seem to extend as far out**