Cosmic rays in the Orion-Eridanus superbubble

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The nearby Orion-Eridanus superbubble, blown by the supernovae and winds of Orion's massive stars, has likely produced cosmic rays and altered their diffusion in the highly turbulent medium. Yet, the analysis of the Fermi LAT data yields a γ-ray emissivity spectrum of the gas inside the bubble that agrees with the average measured in the broader, but still nearby interstellar medium of the Gould Belt. This uniformity calls for a detailed assessment of the past supernova rate and of the particle propagation in and around the superbubble.
The Orion-Eridanus superbubble

The ~12 Myr-old superbubble [3] has been blown by the supernovae and supersonic winds of Orion's massive stars. It has likely fostered cosmic-ray acceleration. The large level of MHD turbulence in the bubble can also affect the diffusion properties of cosmic rays. We aim to probe the cosmic-ray flux inside the superbubble by comparing the $\gamma$-ray emission produced in the inner clouds with the average emissivity measured in other interstellar clouds in the solar neighbourhood [1].

Characteristics of the superbubble [3]:
- last 12 Myr : 10-20 Supernovae
- last 12 Myr : 30–100 formed stars with $M \geq 8 M_\odot$
- $d \sim 180$-400 pc
Modelling the γ-ray emission

To this aim, we have used 8 years of Fermi LAT data above 100 MeV, the spatial and spectral distributions of which have been modelled in terms of interstellar emission borne in the different gas phases of 5 clouds (atomic, dark neutral, molecular, and ionized phases). The model includes other ancillary components such as inverse-Compton emission, point sources, and solar and lunar emissions. The atomic and molecular gas phases are traced by radio HI and CO emission lines, the ionized gas by Hα optical recombination lines, and the dark neutral medium from the coupled analysis of the γ-rays and of the dust optical depth derived from the Planck and IRAS observations [4].

**Selection of model components**

**FIT**
- binned max. likelihood
- in 8 energy bins 0.25 GeV-TeV
- energy-dependent spatial & energy resolutions

### Interstellar medium data:
- HI : HI4PI (Bailin et al. 2016)
- CO : CfA (Dame, 2001)
- Dust : Planck + IRAS, optical depth 353GHz (Planck collab. 2016)
- Hα : VTSS, SHASSA, WHAM (Finkbeiner 2003)
- Gamma : Fermi-LAT, 8 years, 250 MeV → 1 TeV, energy-dependent cut in zmax(E) zenith angle

**γ rays > 250 MeV**
Results and prospects

Preliminary results show that the emissivity spectrum is consistent with the average spectrum measured outside the superbubble, in nearby clouds of the Gould Belt. The agreement covers the entire energy range from 250 MeV to 1 TeV, with no hint of depletion at low energies, nor of hardening at high energy. This uniformity calls for a detailed assessment of the recent supernova rate and of the energetics of massive stellar winds in the superbubble [5] in order to estimate the production rate and diffusion lengths of young cosmic rays and to evaluate the need, or not, to advect them away in the Gould Belt or to the halo via the local Galactic wind [6].

References: