Individual External Collaborator Project Proposal

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WG(s) involved in the project: SNR/diffuse Emission

Scientific Project description (up to two pages, all included):

Introduction

The leftovers of supernova explosions (SuperNova Remnants, SNRs) govern the physical and chemical evolution of our Galaxy. An exploding star releases ~10^{51} erg of kinetic energy through some solar masses of metal-rich ejecta that expand supersonically and drive powerful shocks back and forth in the ambient medium (forward shock) and ejecta themselves (reverse shock). The forward shock expands in a "cloudy" environment and interacts with the interstellar inhomogeneities, thus driving different thermal conditions in the shocked plasma and producing a very broad-band elettromagnetic emission which extends from the radio band up to the X-rays (and γ-rays).

On the other hand, the reverse shock interacts with the fragments of the progenitor star expelled at supersonic speed (several 10^4 km/s) in the explosion. The ejecta are chemically enriched of heavy elements synthesized during the life of the progenitor star and during its death, through the explosive nucleosynthesis processes, and "keep memory" of the anisotropies in the SN explosion and of the internal structure of the parent star. Therefore, the complex structures of SNRs contain the imprint of the SN explosion physics, as well as the results of the interaction of the blast wave with the circumstellar material.

We have been performing numerical hydrodynamic simulations of the evolution of SNRs and the observational evidences of knots and jets in SNR ejecta (e.g., Miceli et al. 2013, MNRAS, 430, 2864, Orlando, Miceli et al., 2016, ApJ, 822, 22).

Aim: studying the ejecta bullets of Vela SNR

While in young SNRs the reverse shock is still close to the forward shock and the inner layers of ejecta are generally cold and unshocked, in evolved SNRs the reverse shock has had the time to reach the SNR center and therefore all the ejecta material has been shocked and heated to X-ray emitting plasma temperatures. For this reason, SNRs like the Vela SNR, with an age of ~ 10^4 yr, may provide a complete picture of the distribution of the ejecta inside the remnant, with the great advantage of a large spatial resolution due its proximity (the distance to the Vela SNR is about 250 pc). On the other hand, in middle aged SNRs the mass of the shocked interstellar medium (ISM) is typically larger than that of the ejecta and the bright, soft X-ray emission produced by the interaction of the forward shock with the inhomogeneous ISM dominates the global X-ray spectrum, thus making it difficult to reveal the ejecta emission and to study its properties.

This project is focused on the detailed study of the ejecta X-ray emission in the Vela SNR. Because of its high angular extension (diameter D~8°), the Vela SNR has only been sparsely covered in high spectral resolution X-ray observations. Therefore, it has not been possible to study the distribution of the physical and chemical properties of the ejecta across the remnant. *Our project aims at studying the ejecta bullets within the Vela SNR shell with*. We aim at confirming the jet-like morphology of the Si-rich shrapnel and plan to obtain estimates on its mass and kinetic energy, which are crucial parameters for our understanding of the explosion processes in core-collapse SNe.

Our collaborators in the eROSITA consortium include the group of Prof. Dr. M. Sasaki at the Remeis Observatory and ECAP, Universität Erlangen-Nürnberg. The collaboration between our groups is solid and fruitful, and already produced a refereed paper on Vela Shrapnel G (Garcìa et al. 2017, A&A, 604, 5) and an approved *XMM-Newton* observation on the Vela SNR (PI M. Miceli, to be performed in this observing cycle).

Required data, supporting datasets and/or tools:

eROSITA maps and spectra of Vela SNR (will be provided by the eROSnr WG) for comparison with the theoretical model

List of Potential Collaborators within eROSITA_DE

Manami Sasaki, Werner Becker

Expected Outcome

We will provide detailed hydrodynamic modelling of Vela SNR to obtain deeper level of diagnostics. We have a consolidated expertise in synthesizing X-ray images and spectra from our simulations (e.g., Miceli et al. 2019, Nature Astronomy, 3 236). The results will be published in papers and will be presented at conferences.

Expected duration of the project

We ask for an external collaboration for one year. However, since the analysis and theoretical modelling of extended emission is very complicated, we expect an extension will be necessary.