EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

MATHEMATISCH-
NATURWISSENSCHAFTLICHE
FAKULTÄT

Emmy Noether-Programm
Deutsche Forschungsgemeinschaft
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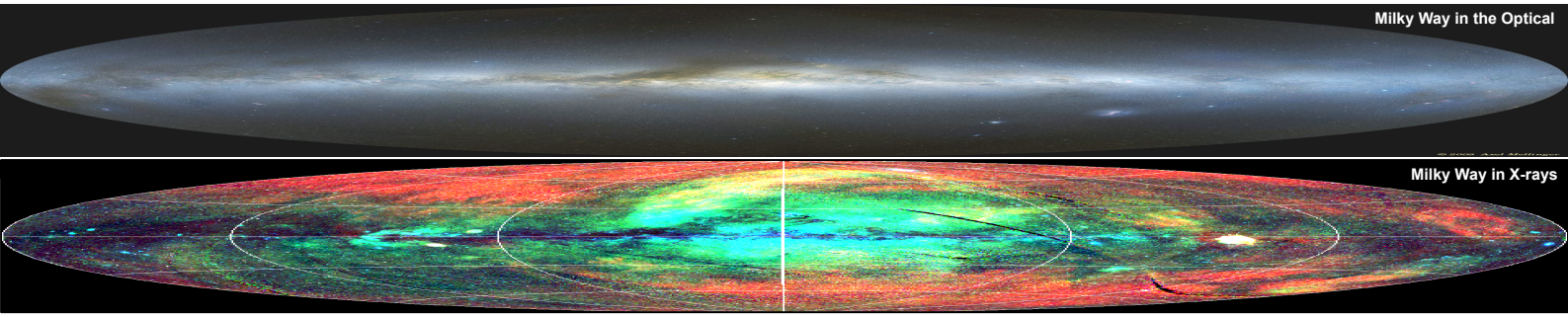
Nearby Galaxies in X-rays: Studying their Components and Global Evolution

Manami Sasaki, Lorenzo Ducci, Patrick Kavanagh, Emma Whelan, Gabriele Warth, Sara Saeedi, Jonathan-Rudolf Knies
Institut für Astronomie und Astrophysik



Emmy Noether Research Group

By studying the components in galaxies and their synthesis, we aim to improve our understanding of the evolution of galaxies and, consequently, of the universe. We use the **X-ray sources in nearby galaxies and in our Galaxy** as observational probes. We analyze archival and new **X-ray** data and perform **multi-wavelength studies** using **radio, infrared, optical, ultraviolet, and gamma-ray** data. The X-ray population study of nearby galaxies opens the door to a better understanding of the evolution of galaxies by detailed modeling of the production of X-ray sources and the evolution of the interstellar medium (ISM) with reliable star formation history constraints.

X-ray Population Studies

Binary systems consisting of a **neutron star** or a **black hole** and a normal star are usually strong X-ray sources and are called **X-ray binaries**. They form the largest and often brightest X-ray population in a galaxy. The population of X-ray binaries hence gives us insight into the stellar content of galaxies. Their X-ray luminosity functions are ideal probes of the **star formation history** of a galaxy.

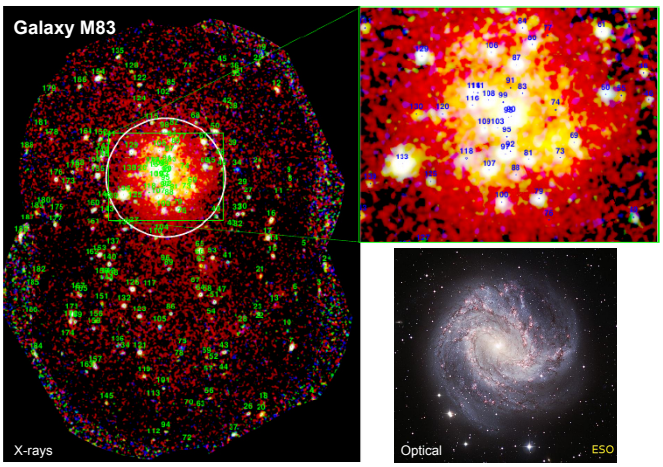


Fig. 1: X-ray sources in the starburst galaxy M83 detected with XMM-Newton (Ducci et al., 2013).

The Hot Interstellar Medium

Supernova remnants (SNRs) and **superbubbles** are generated by one or multiple **stellar explosions** combined with **stellar winds** of massive stars and are driven by the expansion of **strong shock waves** propagating into the ISM. These processes are often correlated in space and time, generating superbubbles and shells of dense gas with extents of typically 100 – 1000 pc.

Since shock waves of SNRs heat the stellar ejecta and the ambient ISM, SNRs are responsible for the energy budget, the chemical enrichment, and the dynamics in the ISM, and thus drive the **chemical and dynamical evolution of galaxies**. In addition, SNRs are sources of **Galactic cosmic rays** as particles are accelerated to highly relativistic energies in their strong shock waves.

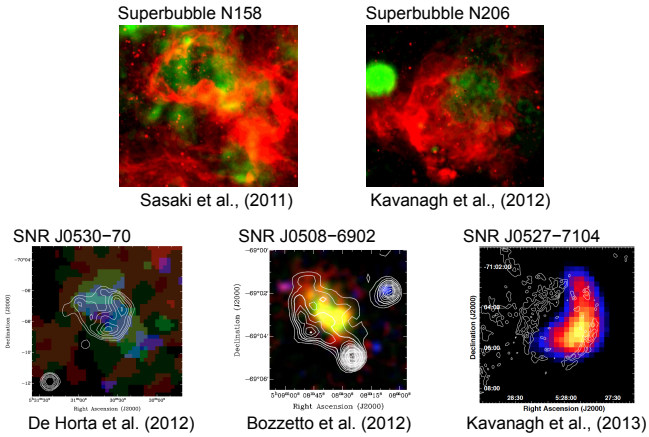


Fig. 2: Upper panel: Hα (red) and X-ray (green) images of two superbubbles in the LMC. Lower panel: X-ray images of SNRs in the LMC with radio (left, middle) or optical (right) contours.

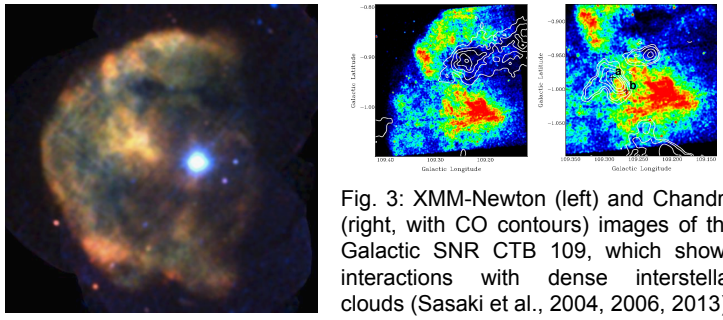


Fig. 3: XMM-Newton (left) and Chandra (right, with CO contours) images of the Galactic SNR CTB 109, which shows interactions with dense interstellar clouds (Sasaki et al., 2004, 2006, 2013).

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University of Tübingen · Faculty of Science
Kepler Center for Astro and Particle Physics
Institute for Astronomy and Astrophysics