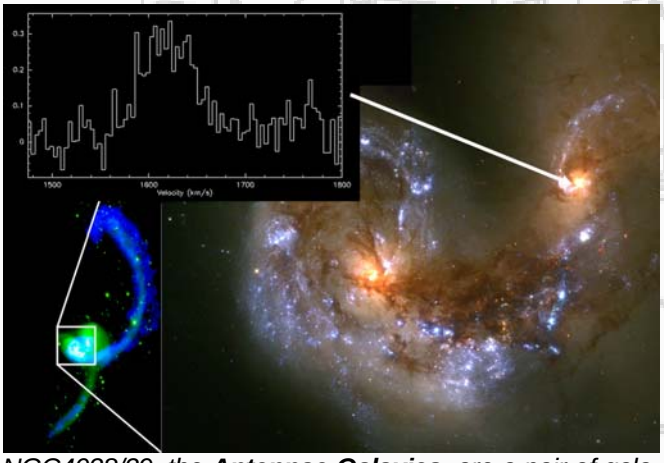
Extragalactic Astronomy

The nature of activity in the optically obscured nuclei of galaxies has been a center field of research for many years. The sources of energy in these regions derive from bursts of star formation, an embedded active galactic nucleus (AGN), or a combination of both. While such phenomena have always been considered interesting, though exotic, it is now recognized that star bursts and AGN activity are crucial phases in the evolution of galaxies. Difficult to observe at optical wavelength due to the intervening dust, these sources are prime targets for a submillimeter facility like APEX: equipped with state-of-the-art detectors in the wavelength range 0.3 – 1.2mm, from the outstandingly good site in the High Andes, APEX will perform studies of the nuclei of nearby and distant galaxies in unprecedented detail and sensitivity.

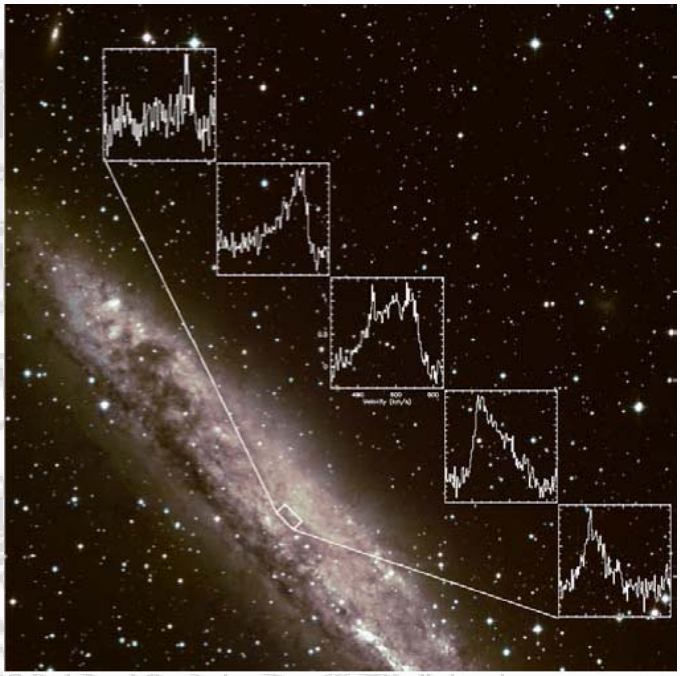
The very first spectra taken with APEX in only minutes of integration time reveal the huge potential of the instrument in exploring the nearby universe. Analysis of the submillimeter spectra of galactic nuclei like NGC 4945 and NGC 253 will help to model the star formation process in and the evolution of these unique objects, a necessary step to also gain better insight into the evolution and physics of far-distant galaxies in the early universe.

Colliding Galaxies



*NGC4038/39, the **Antennae Galaxies**, are a pair of galaxies in violent collision (distance: 90 million light years towards the constellation of Corvus). The long tails of gas and stars are the result of the collision and tidal forces. Towards the center of the face-on collision, where star formation has been triggered in colliding gas streams, APEX has detected warm carbon monoxide CO(J=4-3) - probing the physical conditions of the gas in the interface region between the colliding galaxies.*

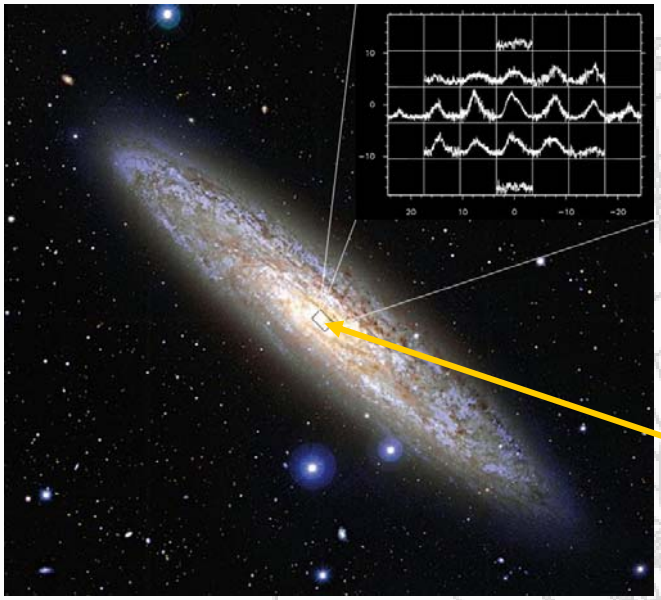
Warm Gas in NGC 4945



*In the nucleus of the nearby spiral galaxy **NGC 4945** (at a distance of 13 million light years, in Centaurus) APEX has detected the emission of atomic carbon CI(1-0) at 492 GHz. NGC 4945 closely resembles the Milky Way, but hosts a more active galactic nucleus (AGN), probably powered by a million solar mass black hole, and has experienced a strong nuclear star burst some million years ago. Their combined radiation fields interact with the molecular clouds in NGC4945, making its nucleus one of the brightest submillimeter sources in the southern sky.*

The spectra of atomic carbon – which is one of the most important coolants of the neutral interstellar medium – reveal the emission from massive warm clouds (300 million solar masses). Deeply obscured by interstellar dust and mostly invisible at optical wavelengths, new stars are forming vigorously and the equivalent of one solar mass is transformed every year into new stars. [The shift of velocity in the spectra, reflects the rotation curve of the targets around the central mass condensation of 3 billion solar masses.]

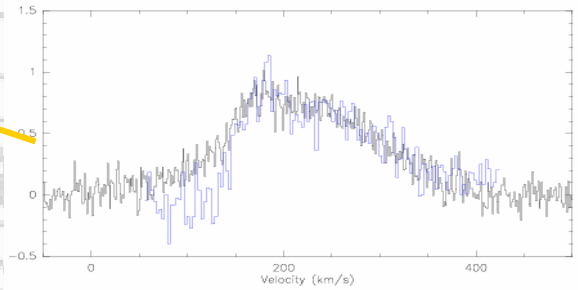
Studying the nuclear starburst in NGC 253



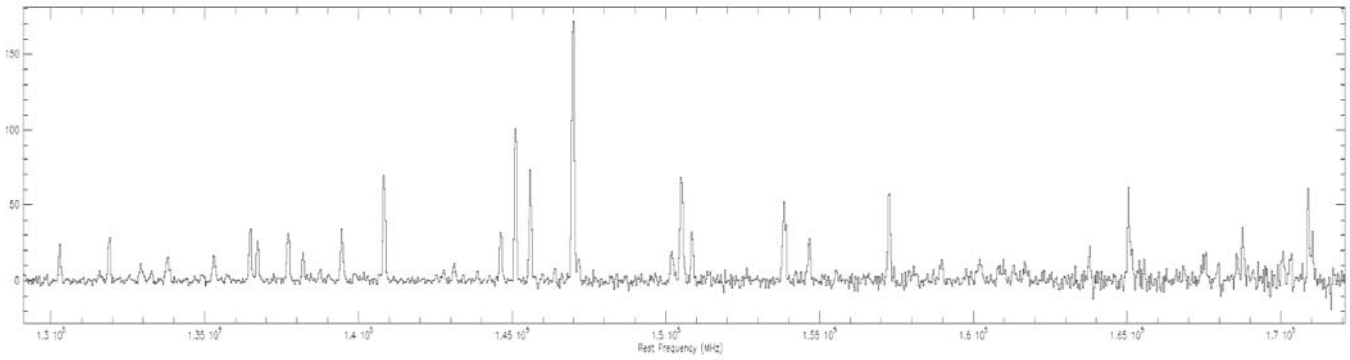
*Less than 10 million light years away, located in the southern constellation of Sculptor, **NGC 253** is one of the nearest spiral galaxies. Because of its high star formation rate and the dense gas clouds in its nucleus (here observed in CO(4-3) at 462GHz), NGC 253 is considered a prototype star-burst nucleus.*

The molecular gas, exposed to the radiation of the young stars, is exceptionally warm and dense. Its proximity makes the source unique for studies of its chemistry and the physical conditions in the star forming clouds.

The λ=2mm "spectral scan" shown below illustrates the chemical complexity: numerous molecules like HCN, CS, H_2CO and their isotopomeres have been detected so far, and APEX will extend the search into the denser warmer gas layers closer to the star burst centers.



During its commissioning APEX has detected the excited transitions of carbon monoxide (J=4-3,7-6) and of atomic carbon CI(1-0) at 492GHz (black) and CI(2-1) (blue) at 809GHz towards the nucleus.



Millimeter wavelength "spectral scan" towards the nucleus of NGC 253 between 129 and 172 GHz (achieved with the IRAM 30m-MRT, Martin et al.), revealing the complex and rich chemistry of the molecular clouds. Also, in preparation of the Herschel-Satellite Mission (ESA 4th cornerstone), APEX will extend and complement these studies to submm wavelengths, zooming-in into the higher density and warmer gas layers closer to the AGN.

Credit for Figures: NGC4038/39. right: Brad Whitmore (STScI) and NASA(Wide Field Planetary Camera 2; composite)
left: NRAO/VLA/CTIO/J. Hibbard et al; optical (green & white) + radio HI (blue) image.
NGC 253: Canada-France-Hawaii Telescope (CFHT)
NGC 4945: ESO PR Photo 18a/99 MPG/ESO 2.2m + WFI

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