Submm extragalactic line surveys of near galaxies: A tool for multifrequencies studies

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Introduction

A spectrograph separates the different wavelengths of light before they hit the detector. Spectroscopy break light into spectra. Spectra can be used to estimate chemical composition, determine one object age, or a galaxy distance.

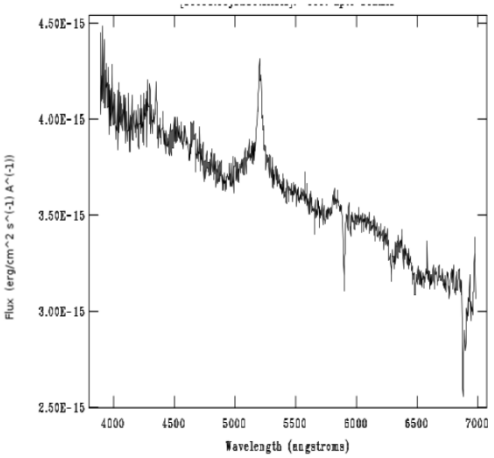


Fig. 1 Spectra of the Blazar 3C 454.3 .
Villicana-Pedraza, I. et al. 2017 (1)

Basic concepts

- A blazar is a region at the center of a galaxy, it emits powerful jets of radiation in the direction of the Earth.
- A starburst galaxy is a Galaxy undergoing a rapid burst of star formation.
- A Seyfert galaxy is a spiral galaxies with unusually bright, small cores that fluctuate in brightness. Contain broad emission lines of highly ionized atoms. At the core contain supermassive black holes with masses as high as a billion solar masses.

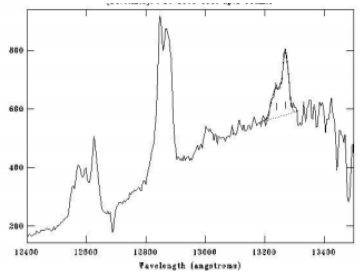


Fig. 2. Spectra of the Seyfert galaxy NGC 1068 observed at the near infrared band using the Gemini telescope.
Villicana-Pedraza, I. et al., 2018 (2)

- ULIRG: ultraluminous infrared galaxies

Molecular Spectroscopy

I studied a line survey observed with the APEX telescope from 270-370GHz. The survey included near galaxies such as the starburst NGC 253, the Seyfert galaxy NGC4 945 and the ULIRG Arp220.

I found in NGC 253, 150 transitions of 26 molecules. For NGC 4945, 136 transitions of 24 molecules, and 64 transitions of 17 molecules for Arp 220. Column densities, rotation temperatures and abundances have been determinated.

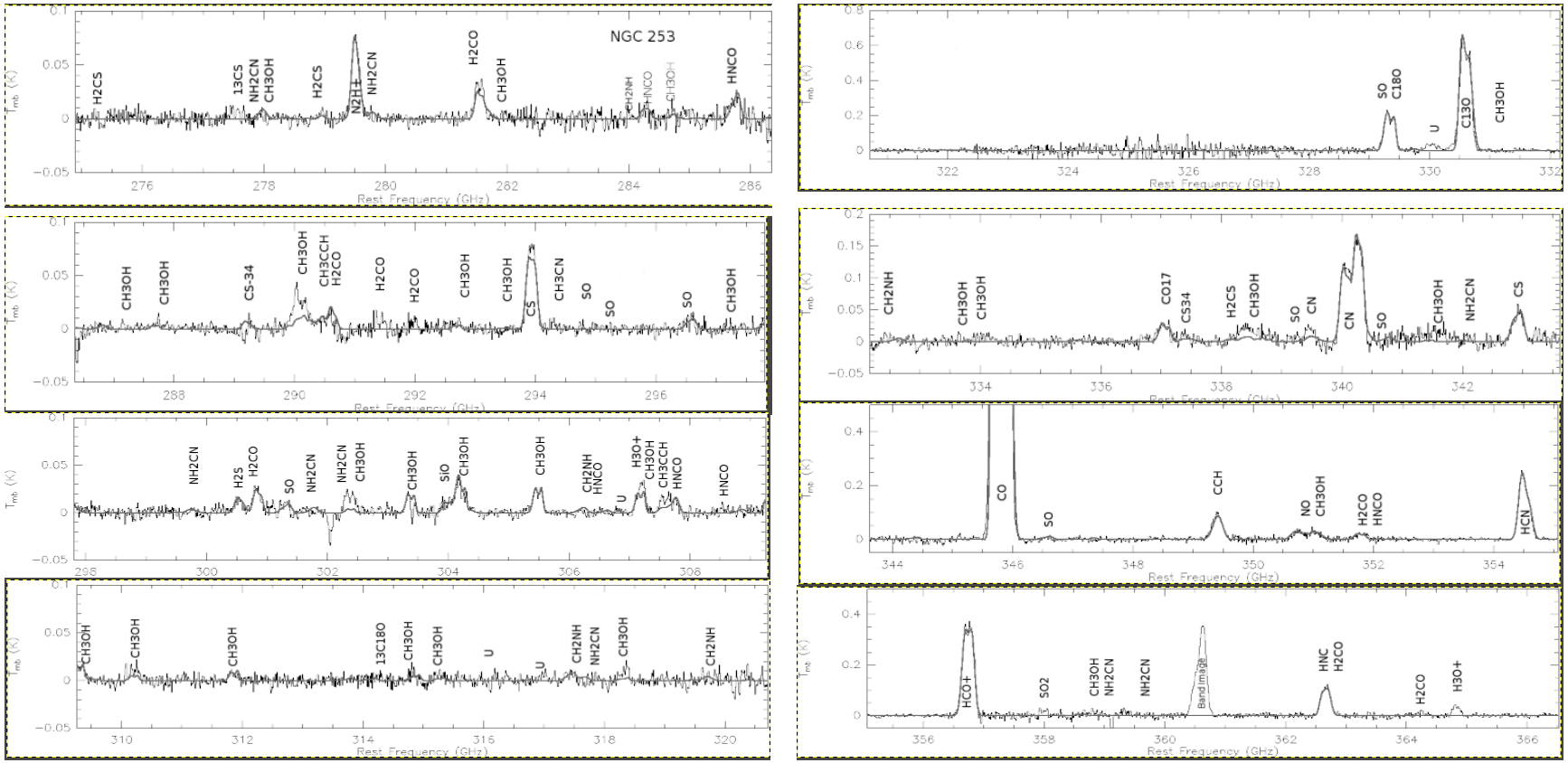


Fig. 3. Molecular identification for the starburst galaxy NGC 253 from 270-320GHz. Villicana-Pedraza, I. et al. 2015 (4), 2017 (5), 2020 (6).

The Fit and the temperature

- We can fit every line to obtain detailed parameters . Also, we can calculate the rotation temperature using similar telescopes. In the example, using the conversions I can work with APEX data and IRAM data to complete the information for the CS molecule from 3mm, 2mm and 1m.

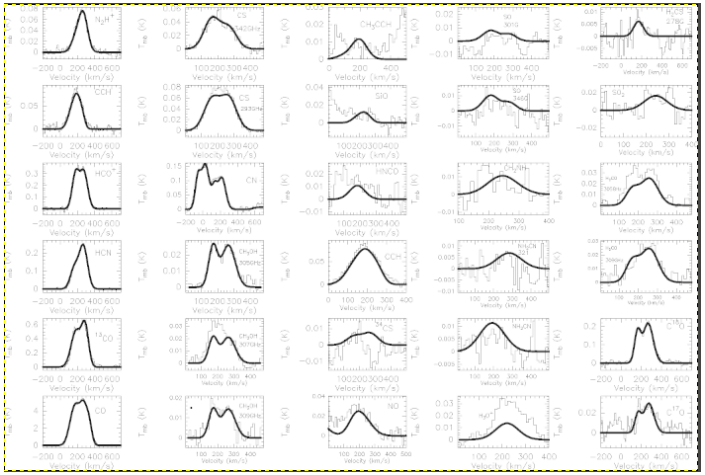
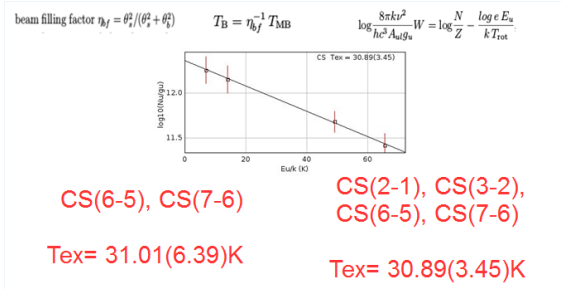


Fig. 4. Fits for NGC 253



Using the experience to train younger students

I am convinced that train and teach young students from all the fields (not only STEM students), they can be in love of astronomy. In this way the will convert to STEM or will support the STEM projects in the future. I use some spectra from the SDSS (Sloan Digital Sky Survey) to practice and train the students for the introductory class.

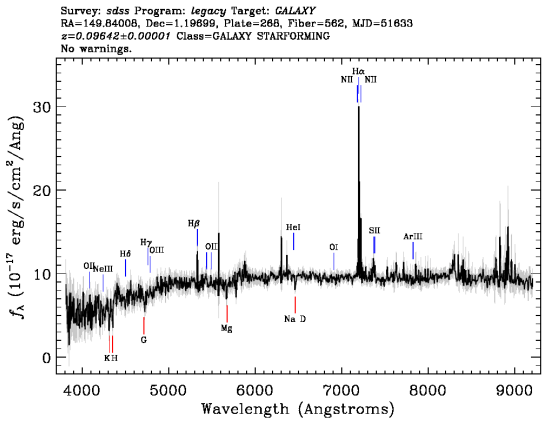


Fig. 5. Spectra of one galaxy observed with the SDSS (7)

Conclusions and References

Conclusions

1. I found in NGC 253, 150 transitions of 26 molecules. For NGC 4945, 136 transitions of 24 molecules, and 64 transitions of 17 molecules for Arp 220. Column densities, rotation temperatures and abundances have been determinated.

2. The differences found in ratios between the Galactic Center and the starburst galaxies NGC 4945 and NGC 253 suggest that the gas is less processed in the latter than in the Galactic Center. The high 18O/17O ratios in the galaxies NGC 4945 and NGC 253 suggest also material less processed in the nuclei of these galaxies than in the Galactic Center. This is consistent with the claim that 17O is a more representative primary product than 18O in stellar nucleosynthesis.

3.I report, for the first time, the tentative detection of the molecular ion HCNH+ (precursor of HCN and HNC) toward a galaxy, NGC4945, abundance explain the claimed enhancement of HCN abundance in the AGN, due to the enhancement of the ionization rate by X-rays.

4. I am using my experience in spectroscopy to teach my undergraduate students how to identify features from different spectra from the SSDS.

References

- **1)** Villicaña-Pedraza, I.; Carreto-Parra, F.; Carramiñana, A.; Saucedo-Morales, J. "Multifrequency Study of the Blazar 3C 454.3". *Galaxies* **2017**, *5*, 3.
- **2)** Villicana-Pedraza, I., Mast, D., Diaz, A., Carreto-Parra F. "Connection between the Circumnuclear Star-Forming Regions and the active nuclei in NGC 1068". 2018. arXiv eprint 1801.08246.
- **3)** "ASTRO3". Seeds, M., Backman, D. Ed. Brooks/Cole, Cengage Learning. ISBN: 978-1-337-09750-5

4) "Submillimetric study of nearby galaxies",
Villicana-Pedraza I., Ph. D. Thesis, 2015.
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- **5)** Villicaña-Pedraza, Ilhuiyolitzin , Martin, Sergio…Carreto-Parra F. "0.8mm extragalactic surveys of nearby galaxies". *Formation and Evolution of Galaxy Outskirts. IAU Symposium. 2017.* 321, 305.
- **6)** Villicaña-Pedraza, I.; Carreto-Parra, F. "Submillimetric study of nearby galaxies". 2020. *RNAAS*
- **7)** SDSS page https://www.sdss.org/education/