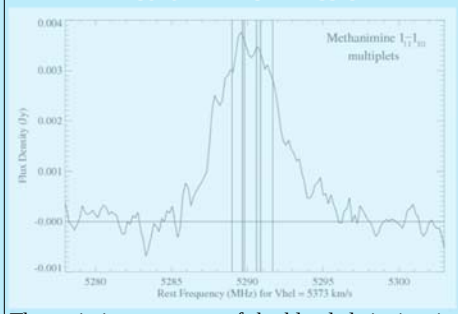
Arecibo Molecular Line Search of Arp 220: The Discovery of Pre-Biotic Molecules

E. Momjian, C. Salter, T. Ghosh, B. Catinella, M. Lebron, M. Lerner & R. Minchin
(NAIC-Arecibo Observatory)

ABSTRACT

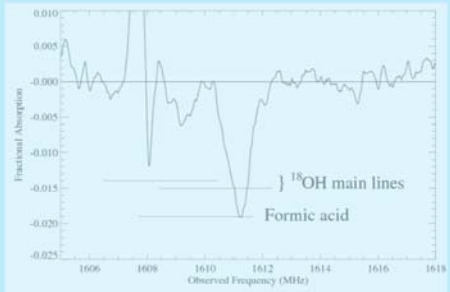
An on-going Arecibo line search between 1.1 and 10 GHz of the prototypical starburst/megamaser galaxy, Arp 220, has revealed a spectrum rich in molecular transitions. These include the pre-biotic molecules: methanimine (CH_2NH) in emission, three v_2=1 direct l-type absorption lines of HCN, and an absorption feature from either ^{18}OH or formic acid (HCOOH). In addition, we report three transitions of λ4-cm excited OH not previously detected in Arp220 which are seen in absorption, and a possible absorption feature from the 6.7 GHz line of methanol. Our results mark the first distant extragalactic detection of methanimine, a molecule with high relevance to the origins of life. Further, the strong, previously undetected, cm-wave HCN lines can aid the study of dense molecular gas and active star-forming regions in this starburst galaxy.

Methanimine Emission



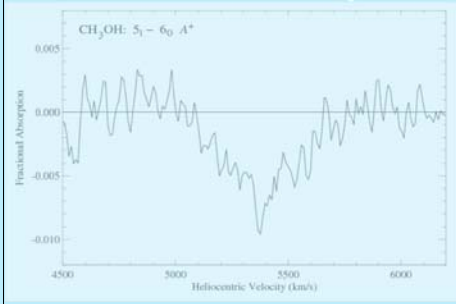
The emission spectrum of the blended six 1_{10}–1_{11} multiplet transitions of methanimine (CH_2NH). The six transitions are indicated by vertical lines. This detection very likely represents a megamaser emission, similar to that of formaldehyde in Arp 220. Methanimine is a pre-biotic molecule which can form the simplest amino acid, glycine (NH_2CH_2COOH), either (1) by first combining with HCN to form aminoacetonitrile (NH_2CH_2CN), with subsequent hydrolysis, or (2) by directly combining with formic acid.

Formic Acid or ^{18}OH Absorption?



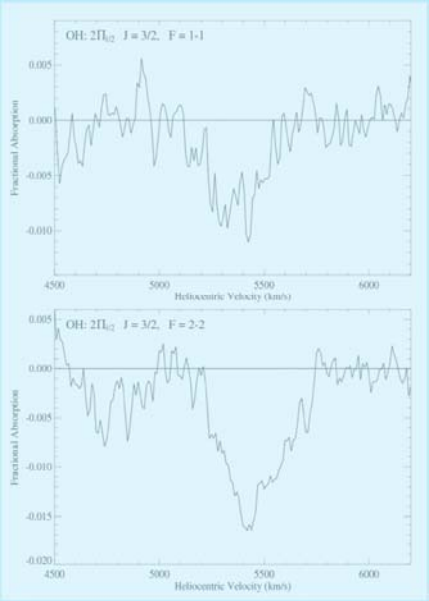
This absorption line(s) could be either formic acid or ^{18}OH. Their expected locations are indicated by horizontal bars. The band is affected by RFI from Glonass at ~1605 MHz but the authenticity of the dominant absorption feature has been verified by its non-appearance in the spectra of the bandpass calibrator.

6.7 GHz Methanol Absorption

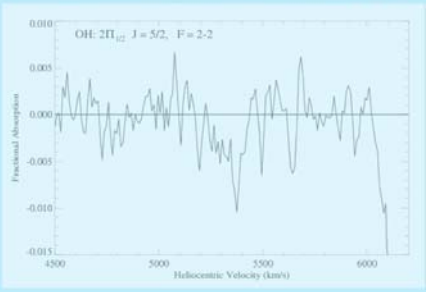


Possible detection of the 5_1–6_0 A^+ (6.7 GHz) methanol line in absorption in Arp 220. If confirmed, this will be the first 6.7 GHz methanol detection beyond the local group.

λ4-cm Excited OH Absorption Lines



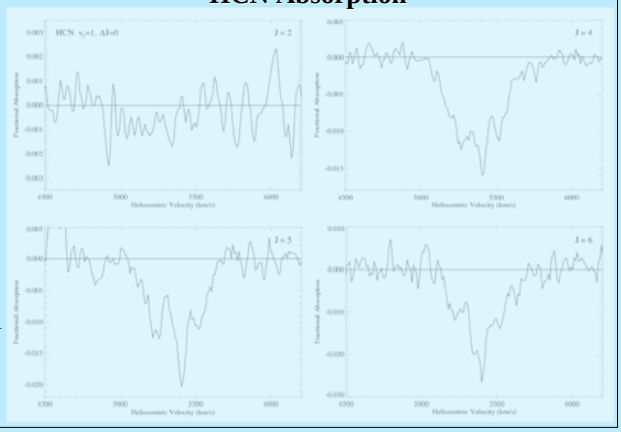
First detection in Arp 220 of the λ4-cm excited OH transitions $^2\Pi_{1/2}$, J=3/2, F=1–1 and 2–2.



First detection in Arp 220 of the λ4-cm excited OH transitions $^2\Pi_{1/2}$, J=5/2, F= 2–2.

HCN Absorption

The spectra to the right show the first astronomical detection of the v_2=1 direct l-type absorption lines of HCN with vibrational levels J=4, 5 and 6. The non-detection of the J=2 vibrational level is also included in the figure.



Observations

- Used various receivers on the Arecibo 305-m telescope to make an almost-complete spectral scan of Arp 220 between 1.1 and 10 GHz, with a spectral resolution of 24.4-kHz.
- Employed the WAPP spectrometer in its recently-commissioned "dual-board" mode that enables the use of eight, 100-MHz boards, to cover a band of 800 MHz at a single time, recorded in both orthogonal polarizations.
- Observed via a modified version of the Double Position Switching technique; a 5-min on/off observation is made on Arp 220, followed by a 1-min on/off on the bandpass calibrator, J1531+2402.