X-RAY OBSCURATION VS MOLECULAR GAS DISTRIBUTION IN LOCAL AGN

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ABSTRACT. We present a study aiming at measuring the correlation between X-ray absorption and absorption due to the presence of molecular gas from larger scales in the host galaxies of nearby AGN. The study will be carried out through the hard X-ray selected AGN in the IBIS AGN CO survey (IBISCO), focusing in particular on those AGN identified as "ideal targets", i.e. those where there are indications that structures in the host galaxy (i.e. edge-on configuration, bars, rings, dust lanes, filaments, merging events) can significantly contribute to the total amount of absorption measured in the X- rays. For the X-ray absorption measurements, we use mainly broad-band spectra obtained by Swift-XRT in conjunction with high energy data (NuSTAR/INTEGRAL) both from archival and proprietary observations, while in the mm regime we employ available ALMA and NOEMA (proprietary and archival) data, as well as IRAM-30m data. ALMA and NOEMA data are spatially resolved and are crucial in order to reveal gas/dust structures not visible in the optical; they also allow to study the absorption spatial variability. IRAM-30m data can instead give an overall estimate of the molecular gas in the host galaxies.

The IBISCO sample. The IBISCO (IBIS AGN CO Survey) is a sample of hard X-ray (20-100 keV) selected AGN extracted from the INTEGRAL/IBIS AGN survey (Malizia+12,16). The INTEGRAL AGN survey is minimally biased against absorption along the line of sight, thus allowing unbiased population studies, and scaling relation studies with other wavebands.

All IBIS sources have:

- a securely identified optical counterpart;
- optical spectra, therefore allowing for secure redshift measurement, identification and classification;
- X-ray data available, allowing measurements of the intrinsic nuclear absorption.

The IBISCO sample consists of 57 objects, selected according to these criteria:

- they have z<0.05;
- they are located at Dec>-20°;
- IRAM 30-m observations available for the whole sample; NOEMA and ALMA data available for the majority of sources;
- all have BH mass estimates and $L_{Bol}>10^{43}$ erg/s.

AIM. Collect all available sub-mm and X-ray data in order to study possible correlations between absorption estimated from cold molecular gas (CO) in the host galaxy (on scales from a few pc to kpc) and absorption measured in the X-rays (on pc scales, i.e. disk, broad line region and torus).
Following the first such study by García-Burillo+21 (GATOS I), we aim at enlarging the sample by using in the first instance IBISCO and then by using an even larger sample provided by Koss+21.
The comparison between GATOS and IBISCO (Fig.1) makes use of ALMA and NOEMA data, therefore probing smaller scales, but since our goal is to investigate possible contribution to the X-ray column density from material located on larger scale, we make use of the IRAM-30m proprietary observations.
As a further step we considered the sample by Koss+21, which has an even larger number of sources (~200 AGN), with mm data acquired by single-dish observations.
X-ray column density measurements were obtained through proprietary data for IBISCO (XRT/XMM/NuSTAR+INTEGRAL/IBIS), and through broad-band measurements from Ricci+17 (XRT/XMM/Chandra+Swift/BAT) for the Koss+21 sample.

First Step Analysis

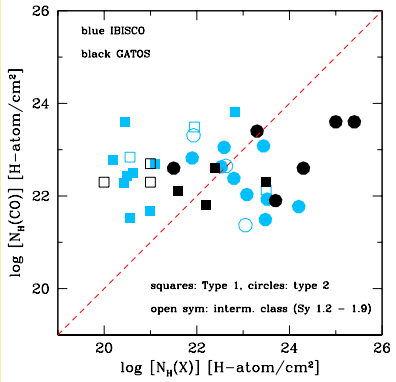

Fig1. IBISCO & GATOS samples. GATOS data alone show a positive correlation coefficient (Pearson test) of ~0.6. When the IBISCO sample is added, the coefficient drops to 0.13, hinting at most at a weak correlation.

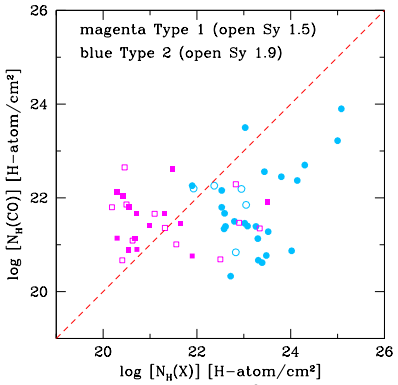

Fig2. Log(N_{HX}) vs Log(N_{HCO}) for the IBISCO sample. Sub-mm data are from IRAM. The Pearson test gives a correlation coefficient of 0.26, suggesting again a mild correlation between N_{HCO} and N_{HX}.

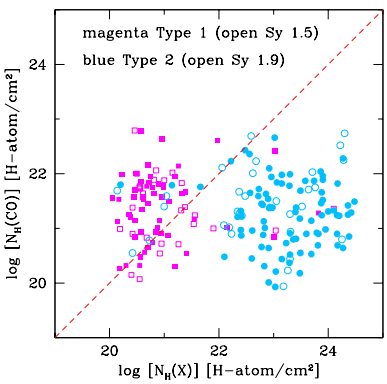

Fig 3. Koss+21 sample, N_{HCO} from APEX and JCMT, while N_{HX} is measured from X-ray spectra in Ricci+17. The Pearson test gives a correlation coefficient of -0.0013, hinting at a possible anti-correlation between N_{HCO} and N_{HX}.

Early results

From the initial analysis of the IRAM data for the IBISCO sample, there is no strong evidence for a correlation between N_{HCO} and N_{HX}.
However it is clear that Type 1 and Type 2 AGN occupy two different areas of the N_{HCO} vs N_{HX} plot, as already pointed out by García-Burillo+21. This is even more evident, when one considers a larger sample as shown in Fig. 3.
While the distribution of N_{HX} is the one expected from the Unified Model of AGN, the N_{HCO} distribution does not show a significant difference between Type 1 and Type 2 AGN (see Fig. 4).

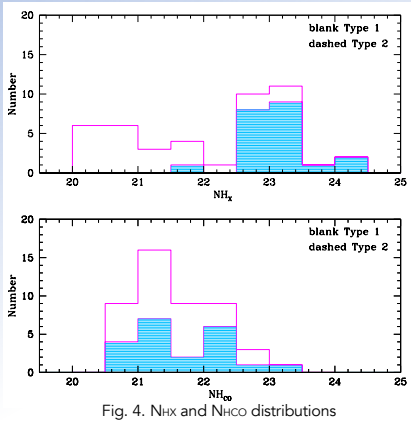

Fig. 4. N_{HX} and N_{HCO} distributions

Where do we go from here?

- Try to reduce as much as possible uncertainties in the conversion CO-to-H_2;
- Try to understand which is the best scale (hundreds of pc?) where to measure the amount of cold molecular gas;
- What is the main reason of N_{HX} and N_{HCO} behaving differently?
- Try to select ideal targets where there are indications of structures in the host galaxy, such as bars, rings, dust lanes, filaments and/or edge-on configuration or even evidence of merging events that can significantly contribute to the total amount of absorption measured in the X-rays.

References.
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