Astrophysical Masers:
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X-Ray Characteristics of Water Megamaser Galaxies

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Abstract. We have compiled the X-ray characteristic properties for a unique and homogeneous sample of Type 2 AGN with water megamaser activity observed by *XMM-Newton* and for a control sample of non-maser galaxies, both analyzed in a uniform way. A comparison of the luminosity distributions confirms previous results (from smaller and/or less systematic studies) that water maser galaxies appear more luminous than non-maser sources. In addition, the maser phenomenon is associated with more complex X-ray spectra, higher column densities and higher equivalent widths of the Fe Kα line. Both a sufficiently luminous X-ray source and a high absorbing column density in the line of sight favor the appearance of the water megamaser phenomenon in AGN.

Keywords. masers, galaxies: active, galaxies: Seyfert, X-rays: galaxies; cosmological parameters

1. Introduction

Water maser galaxies are a rare subclass of Active Galactic Nuclei (AGN). They play a key role in modern cosmology, providing a unique way to measure geometrical distances to galaxies within the Hubble flow. Modern megamaser observational programs have the goal to measure the Hubble parameter with an accuracy of 3% and to provide a constraint on the equation of state of dark energy (Braatz *et al.* 2008; also Braatz, this volume). An increasing number of independent measurements of suitable water masers is providing the statistics necessary to decrease the uncertainties of such measurements. Studies at X-ray energies have the potential to yield important constraints on target-selection criteria for future maser surveys, promising increased detection rates of new megamaser galaxies.

2. *XMM-Newton* archival survey of megamaser galaxies

We have performed an extensive archival survey of *XMM-Newton* observations of water megamaser galaxies. Based on the sample of Zhang *et al.* (2012) we compiled a sample of maser (30 Type 2 AGN) and a control sample of non-maser (38 Type 2 AGN) galaxies that have been observed with *XMM-Newton*. To avoid biases potentially introduced by having significantly different redshift distributions between the two samples, we cut the maser sample at z = 0.02.

We aim to characterize the spectral features of maser and non-maser galaxies in a systematic study on a larger scale than previous small-sample analyses based on non-uniform data from different X-ray satellites. A comparison shows that megamaser galaxies have notably more complex X-ray spectra than non-maser sources. In Fig.1, we present three

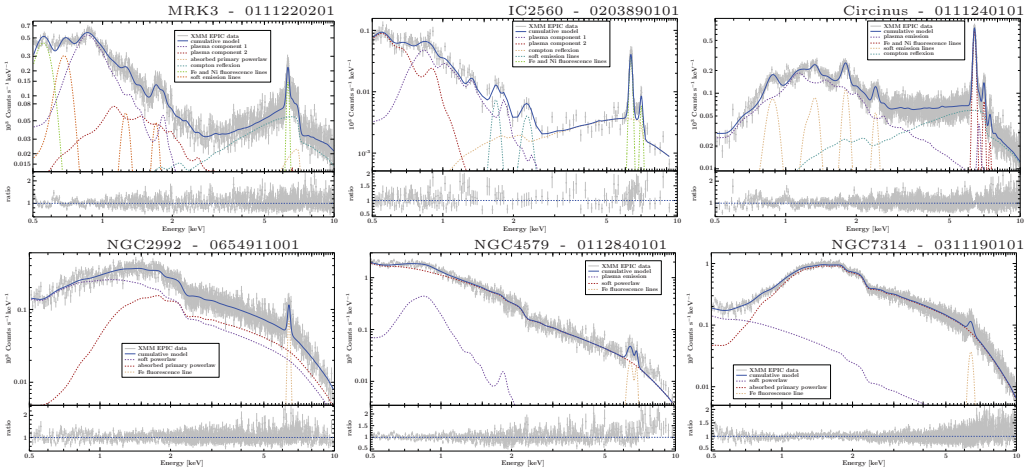

Figure 1. Three examples of *XMM-Newton* X-ray spectra of megamasers (*top panels*) and non-maser AGN (*bottom panels*).

characteristic X-ray spectra from each of the maser and non-maser samples, representing the typical distribution of the spectral components used in each sample. An overview of all maser and non-maser spectra of our study will be provided in Leiter *et al.* in prep.; see also Leiter *et al.* (2014). Typical models of maser X-ray spectra include a highly absorbed power law, multiple ionized plasma emission components, strong Fe lines and X-ray reflection. Furthermore, maser galaxies exhibit a higher fraction of X-ray reflection than non-maser galaxies. Purely reflection-dominated spectra are only observed among masers. On the other hand, non-maser spectra can typically be described by a dominating weakly or partially absorbed power law, ionized plasma emission and emission from neutral iron. Hence, the physical processes in maser sources are generally more complex than in non-maser sources. By estimating the parameters of the best-fit spectral models we can see that the maser phenomenon is also associated with higher column densities and Compton-reflection, which is correlated with a larger equivalent width of the Fe Kα line, and higher intrinsic luminosities. Generally, the maser fraction increases towards high intrinsic luminosities. These findings are in agreement with previous results that found higher absorbing column densities in maser galaxies (e.g. Castangia *et al.* 2013, Greenhill *et al.* 2008, Zhang *et al.* 2006).

Our results suggest that it is possible to define selection criteria for future maser searches based on the complexity of the X-ray spectral model, the absorbing column density, the Fe-line equivalent width, and the intrinsic X-ray luminosity of sources found in upcoming large area sky surveys at X-ray energies like e.g. the eROSITA survey.

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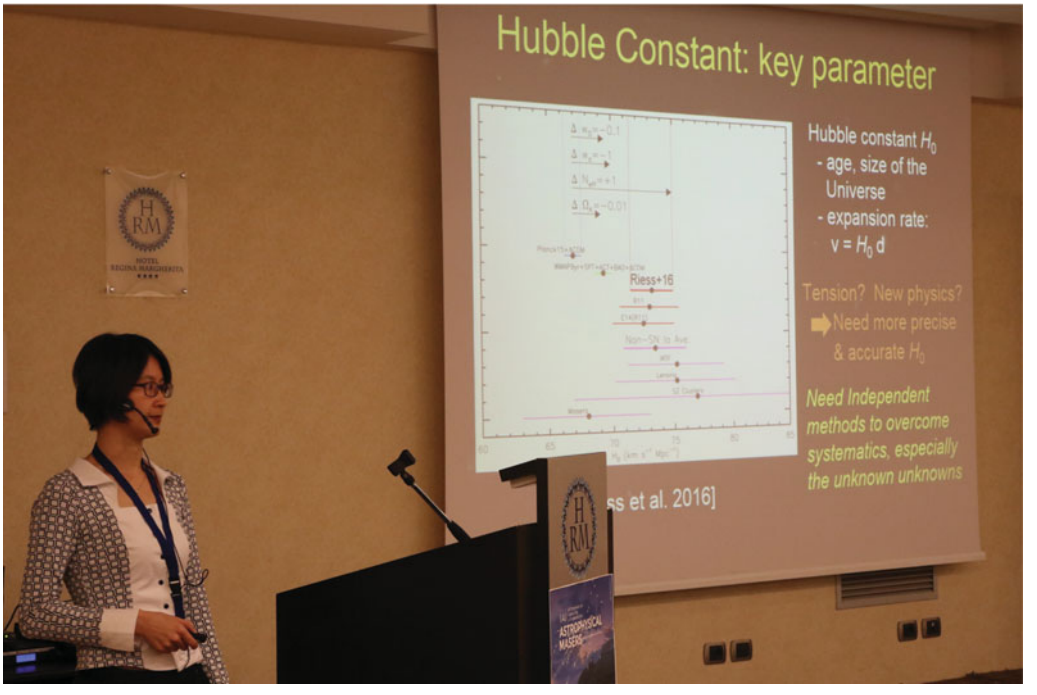

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