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Search for water maser in supermassive black holes of hard X-rays selected Active galactic nuclei

Alice Bizzarri[1], Andrea Cacozzo[2], Fulvio Talarico[1], Loredana Bassani[3], Angela Malizia[3]

[1] Liceo Scientifico A.B. Sabin – Bologna
[2] Liceo Scientifico A.B. Sabin – Bologna
[3] IASF – INAF - Bologna

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ISTITUTO DI ASTROFISICA SPAZIALE E FISICA COSMICA – BOLOGNA
Area della Ricerca di Bologna – via Piero Gobetti, 101 – 40129 Bologna – ITALY
e-mail: segreteria@iasfbo.inaf.it – PEC: inafiasfbo@pcert.postecert.it– www.iasfbo.inaf.it
Tel. (+39) 051.6398688 – Fax (+39) 051.6398724 - Cod. Fisc. 97220210583 – Part. Iva 06895721006

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Introduction

An Active Galactic Nucleus (AGN) is a compact region at the center of a galaxy that has a much higher than normal luminosity and that emits more energy, as electromagnetic radiation, than the rest of the galaxy; about 100 times higher. A galaxy which hosts an AGN is an active galaxy. The radiation from AGN is believed to be the result of accretion of matter by a supemassive black hole at the center of the galaxy. In the local universe about 10% of all galaxies are active.

A phenomenon sometime associated to active galaxies is maser emission. Maser, which is the acronym for "microwave amplification by stimulated emission of radiation", is a phenomenon present in many astrophysical objects and one that can be studied in the microwave-radio part of the electromagnetic spectrum.

Many molecules (water, ammonia, methanol etc) produce maser emission; among these, the astronomical maser produced by water molecule or H_2O is one of the most intense and spectacular. It is produced at 22 GHz (hence observable with radio telescopes) and it has been detected in many astronomical sources including our galaxy and other distant galaxies. The masers associated to our own galaxy are coming from region of star formation or from star that are in the latest part of their evolution; they have low luminosities (less than the luminosity of our Sun). In other galaxies, especially those containing an active nucleus and therefore hosting a supermassive black holes, water maser emissioni is very intense and bright (thousand of times the luminosity of the Sun) ; for this reason they are called Mega-Masers.
Detailed studies of active galaxies showing maser emission have allow to pinpoint the origin of this phenomenon in the nucler part of the galaxy, either in an accretion disk where large amount of matter is directed to feed the supemassive black hole or in a relativistic jet of plasma which is coming out at very high speed from the black hole itself.

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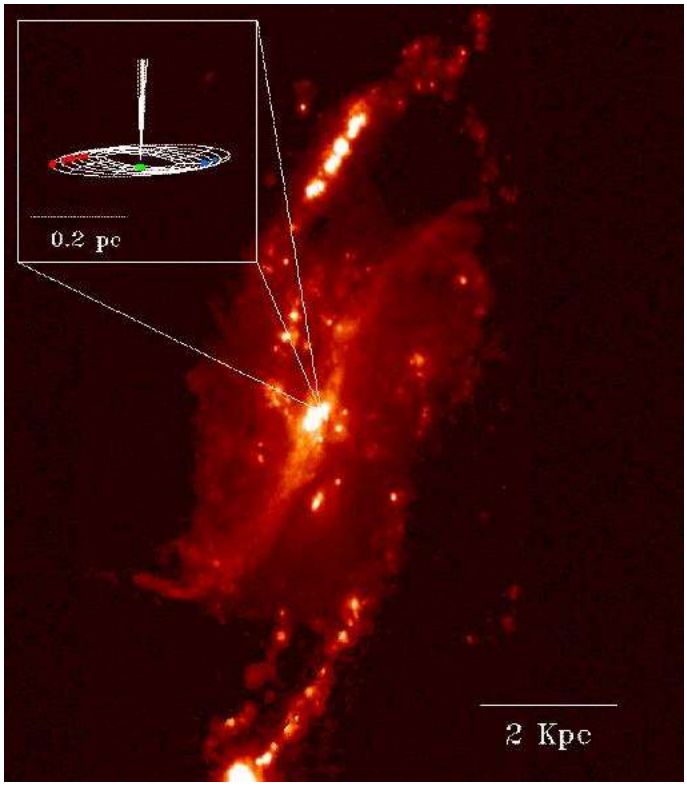
The particular characteristics of water maser emission in active galaxies, like the high luminosity and the compact dimension, make them ideal instrument to use for obtaining information on the geometry and structure of the nuclear part of the galaxy and therefore on the monster (the supermassive black hole) at its center. In the following image we show NGC 4258, the prototype magamaser disk galaxy



[Credits: NRAO/AUI and Gerald Cecil and Holland Ford.]

Aim of the present project is to search for 22GHz water maser emission in a sample of active galaxies likely to host a supermassive black hole at their center. To this purpose we have used the latest survey made by the instrument BAT on board Swift, a NASA satellite. The identification of a group of these systems in the hard x-ray band will allow the astronomers to study in depth their properties and to understand the maser mechanism in more detail.

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Data Analysis

To search for water maser emission in active galaxies we have used the Swift BAT 70-Month Hard X-ray survey catalogue (http://swift.gsfc.nasa.gov/results/bs70mon): this survey contains a total of 1210 of high energy objects the majority of which are of extragalactic nature; in particular 822 objects are associated with active galaxies, likely hosting a super-massive black hole. We divided this sample in 3 parts. Each student was assigned a set of 274 objects divided in Right Ascension (RA): those located from RA=0.0 degrees to RA=104.1 degrees were assigned to Alice Bizzarri, those from RA=104.1 to RA=207.5 to Andrea Cacozza e those from RA=207.5 to RA=360.0 to Fulvio Talarico . For each set of objects, the student searched available archives such as the Megamaser Cosmology Project (MPC project at

https://safe.nrao.edu/wiki/bin/view/Main/MegamaserCosmologyProject

and the literature to look for reports of water maser observation and detection. In this search we have used two main databases (NED1 or NASA/IPAC Extragalactic Database and SIMBAD2 or Set of Identification, Measurements, and Bibliography for Astronomical Data).
We have also searched these databases by coordinates to confirm that the counterpart observed at 22 GHz was the same as that reported in the the Swift/BAT catalogue.

We found that out of a total of 264 observed at 22GHz, 36 display water maser emission. These objects are listed in table 1a,b,c where we report the Swift/BAT name, the BAT source coordinates, the name of the counterpart, the redshift, the Logarithm of the hard X-ray(14-195 keV) luminosity, the source type and the maser luminosity.

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In Table 2a,b,c we report the sources from the BAT sample that were observed at the frequency of interest. In Table 2 we report beside the BAT name, the Bat source coordinates, the counterpart name the redshift, the Logarithm of the hard X-ray luminosity the source type and the maser reference.

Conclusions

13.6% of the 264 BAT active galaxies observed at 22GHz display water maser emission. This is much higher than generally found in the literature (typically of only few percent). So far more than 3000 galaxies have been searched for water maser emission and the detections have been obtained in about 160 AGN, the majority being radio quiet objects classified as Seyfert 2 or Low ionization nuclear emission line regions (LINERS), in the local Universe ($z<0.05$, see data in the MPC project).
In our case, we find that among the active galaxies showing mega-maser emission 22 are of Seyfert 2 class or 6%.
Also note that all the water maser galaxies are located within $z<0.059$

We have also compared the hard X-ray luminosity with the Maser luminosity (figure 1): it shows that brighter hard X-ray emitting AGN have also a brighter maser emission.

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