Andrea Tarchi

Probing the Unified Model for AGN through maser studies

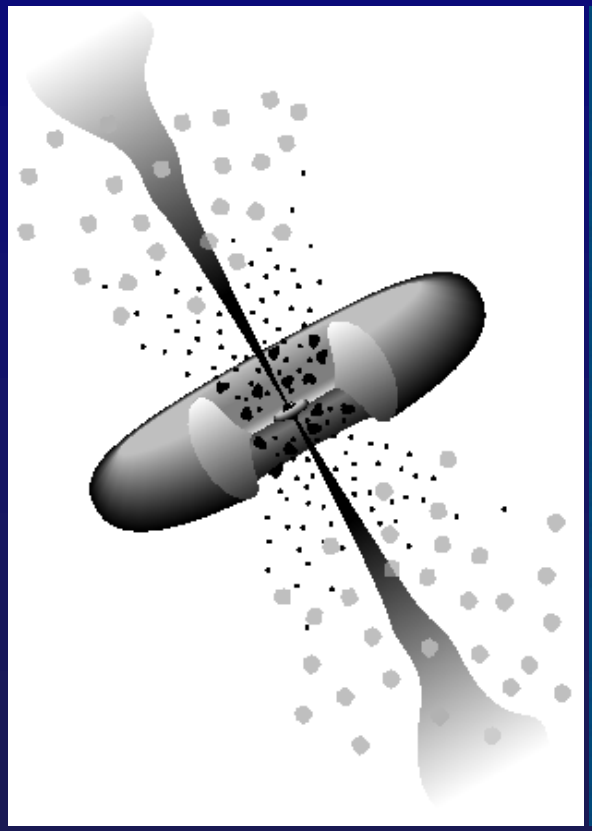
An a***masing*** file

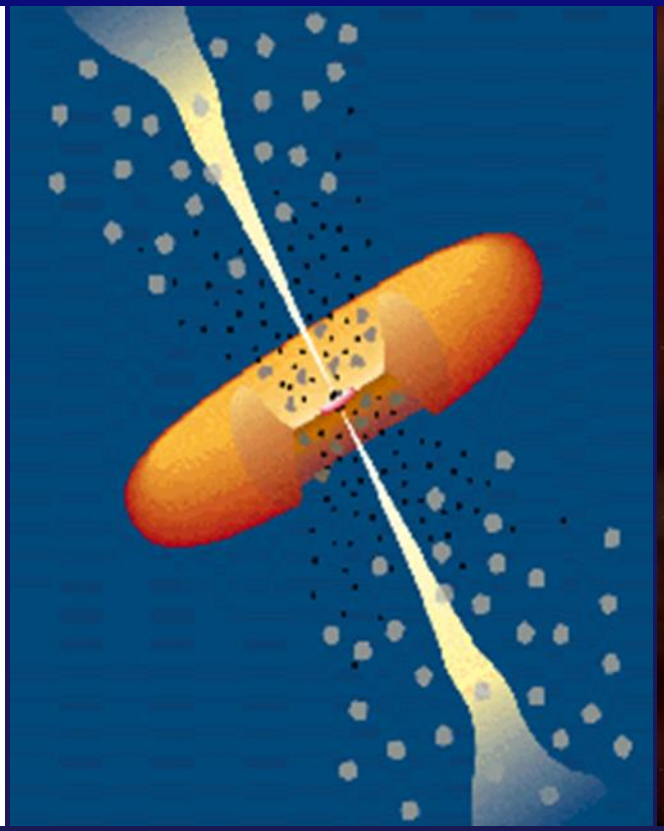
Audizione Schede INAF - RSN1 - AGNMASER - 24 Maggio 2021

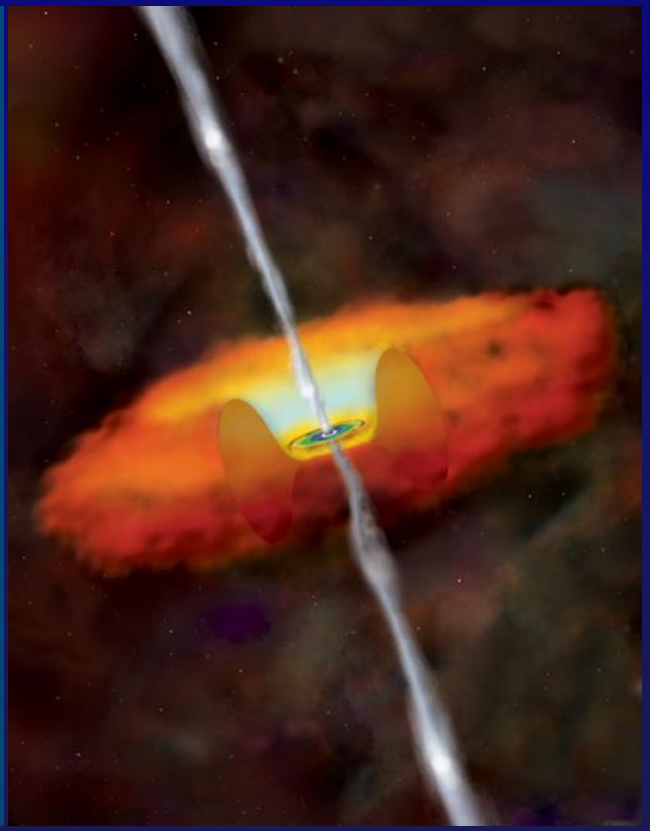
Outline

- Context
  - The Unified Model for AGN (past and present)
  - The H_2O and OH (mega)masers contribution
- Team and products
  - Team composition
  - Data and publication history
  - Milestones and highlights
  - Programme plan and Recent studies
- AGNMASER and INAF
  - Infrastructures and related INAF files
  - INAF leadership
  - Critical issues

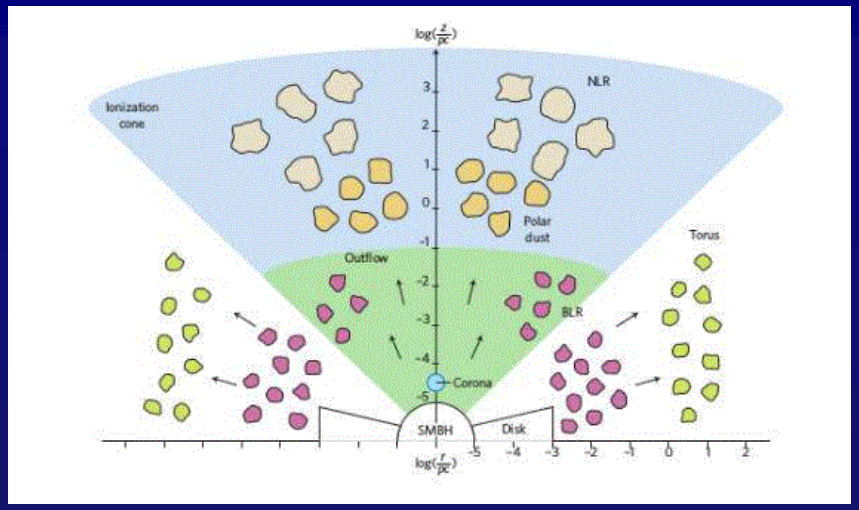
The Unified Model for AGN – past



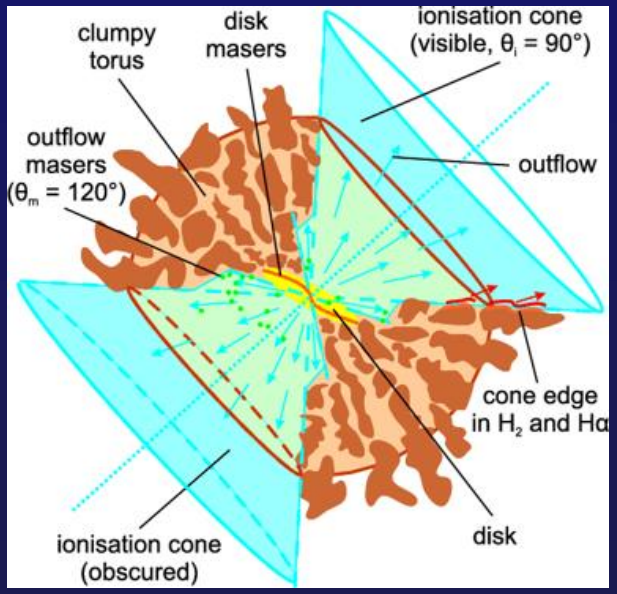




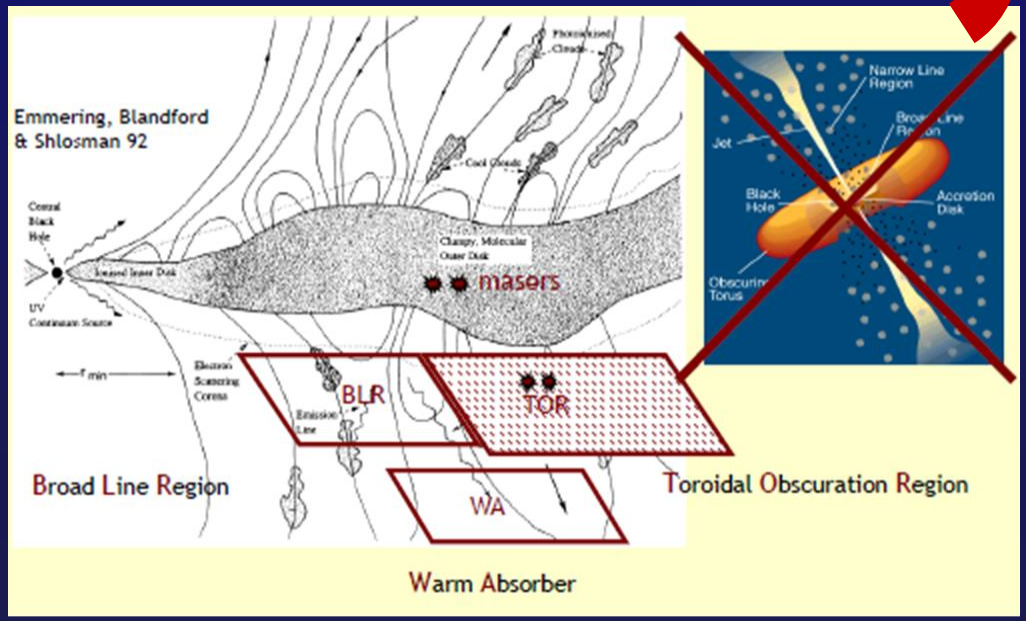
The Unified Model for AGN – present (?)



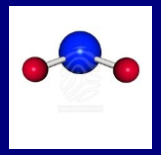
Ramos Almeida & Ricci (2017)



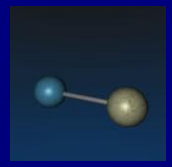
Tristram+ (2017)



(e.g., Nenkova et al. 2008; Elitzur et al. 2006,2012)

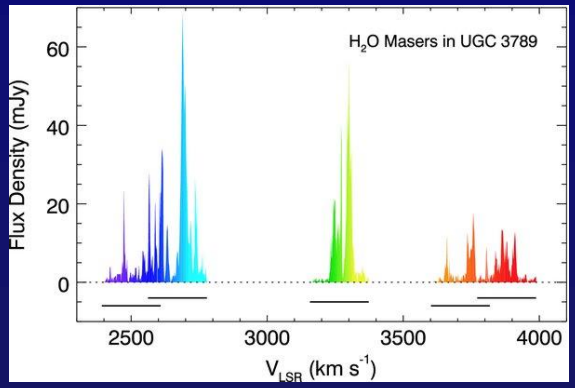


H_2O (and OH) masers in AGN



Disk-masers → **Disk geometry and BH masses**

(e.g. NGC 4258, UGC3789, …)



Jet-masers → **Evolution of the jet**

(e.g. Mrk348, NGC1052, …)

Outflow-masers → **Geometry of the outflow**

(e.g. Circinus)

OH masers → **Rotating dusty torus**

(e.g. Mrk231)

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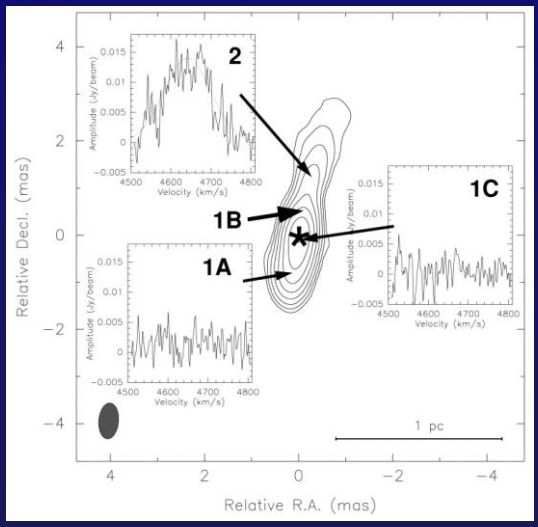

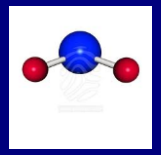

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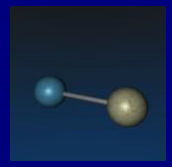

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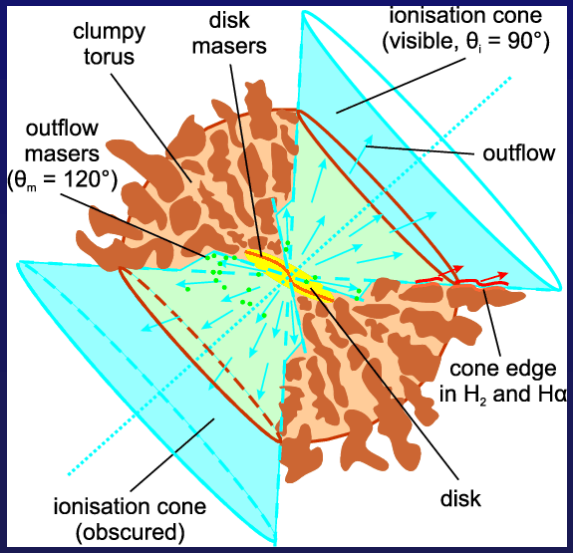

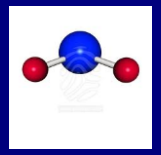

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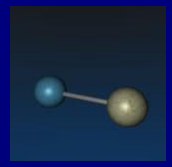

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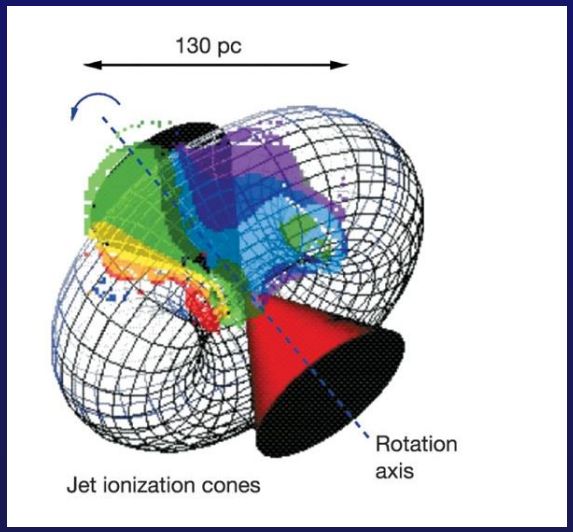

Team composition

OA Brera:
V. Braito (TI)
A. Caccianiga (TI)
R. Della Ceca (TI)
P. Severgnini (TI)

OAS Bologna:
L. Bassani (Associate)
A. Malizia(TI)

OA Cagliari:
P. Castangia (TI)
E. Ladu (Student)
A. Melis (TI; Tech.)
G. Surcis (TI)
A. Tarchi (TI)

IAPS Roma:
Francesca Panessa (TI)

FTE involved within INAF (2021-2023): ~5
Note: the Programme runs since 2001

Team composition

NRAO:
J. Braatz

Uni. Harvard:
D. Pesce (new)

Uni. Kiev:
E. Bannikova (new)

MPIfR:
A. Brunthaler
C. Henkel
K. Menten

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Data and publication history

Past (from 2001):

- **hundreds of hours obtained at the largest radio telescopes (e.g., Effelsberg, GBT, VLA, VLBI, etc …)**
- **data acquired also with high-energy instruments (XMM, Swift, INTEGRAL …)**

-> about 40 refereed papers*, (some 'technological' publications, like the SRT spectroscopic backends commissioning papers)

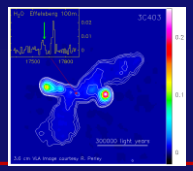
Recent data:

- **VLBA projects BT142 and BT145 (total: 50 hours)**
- **EVN projects ET038, ET045 (+eMERLIN) (total: 70 hours)**
- **SRT project 24-18 and DDT#8-21 (total: 80 hours)**

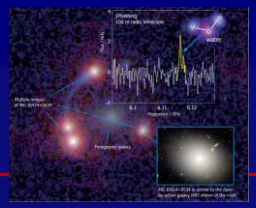
Note: as a possible reference, a Master thesis is presently based on 7 hours of spectral VLBI data (see 'Critical issues')

Milestones and Highlights

Programme starts.
PI introduces AGN maser topic in INAF (work started at MPIfR)



Discovery of first and, so far, only H2O maser in a FRII



P. Castangia joins the programme.
Co-I of Nature paper: maser at z=2.64

Review talk at IAU Symp242
Collaboration with NRAO and F. Panessa

SRT Inauguration
A. Melis joins the Programme

Collaboration with Bologna and Brera

IAU Sym336

G. Surcis joins the Programme as TI in OAC

Papers on promising selection criteria to increase maser detection rates

INAF Audit

2001 2003 2008 2012 2013 2017 2020 Now

Programme plan

Single-dish searches for megamasers in promising AGN samples (AGN masers are rare!)

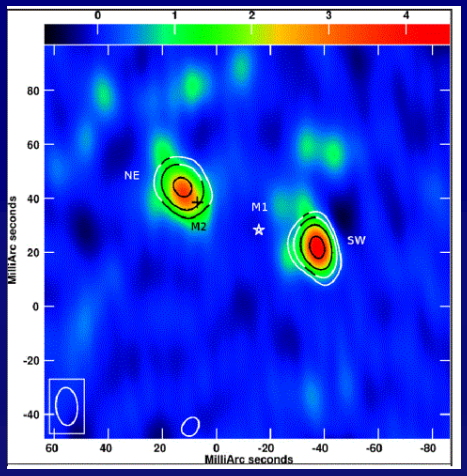
Single-dish monitoring of new (and known) maser sources

Interferometric (VLBI) follow-ups of new (and known) maser sources

Investigation and modelling of innermost components of AGN
-> better understanding of the Unification Model

Correlation studies of maser occurence and AGN charachetristics
-> better knowledge of maser phenomenon & creation of promising samples

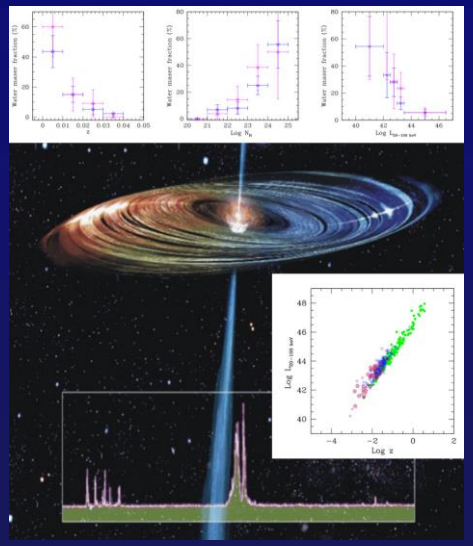
Recent studies of the Team



Sample taken by Severgnini+ (2012) **with the highest maser detection rate**: 50%

A new jet-maser in the nucleus of the Seyfert 2 galaxy IRAS15480-0344.

(Castangia+ 2019 and EVN Newsletter 54 – Sept. 2019)

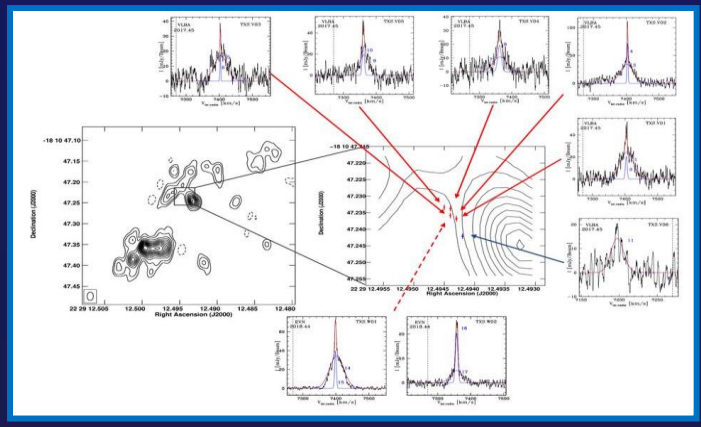


Hard X–ray selection has proven, on a firm statistical basis, to be **extremely efficient in the detection of water masers**.

(Panessa+ 2020 and POM INTEGRAL – Dec. 2020)

VLBA and EVN observations obtained, **for the first time**, the location of the H_2O masers w.r.t. the continuum emission, **shedding light on the nature of the nuclear gigamaser in TXS 2226-184**

(Surcis, Tarchi, & Castangia 2020 and EVN Newsletter 57 – Sept. 2020)

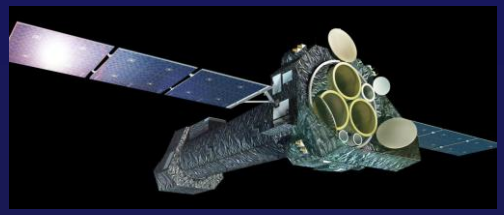


Infrastructures and related INAF files

Single-dish telescopes: Effelsberg, GBT, **SRT**, Tidbinbilla, FAST

Interferometers: **VLBI** (EVN, VLBA), eMERLIN, **SKA** (and MeerKAT), ngVLA

High-energy facilities: XMM, eROSITA, INTEGRAL, Chandra



Other related INAF files: **TORQUA** (PI: Panessa)

INAF Leadership

In 2001, the PI introduces the extragalactic maser topic in INAF. After 20 years:

7 students (PhD, and or Master thesis) supervised on maser topics
-> 3 are now staff members in INAF working on masers

Tens of publications published on masers, sometimes with national and international related press releases and Media and outreach interest

Unique team in INAF (now including members of 4 Institutes) systematically involved in extragal. maser science (including active members of the SKA-SWG)

International partnership estabilished with prestigious research Institutes (e.g., MPIfR, NRAO)

INAF main organizer of the first IAU Symposium on masers in Europe (in Sardinia; 2017)

-> growing visibility of INAF in the programme topic

Critical issues

Team expertises are sufficiently broad and well-complemented:
observational campaigns and data/correlations analysis are confidently within reach of the team

- Data are massive:
VLBI data reduction requires man-power (possibly trained, viz. Postdocs)

- The team knowledge necessary for simulations and modelling is not yet optimal:
New collaborations are ongoing (see Team composition)

- State-of-the-art instrumentation, and extremely sensitive and extended telescope arrays are necessary:
Future strategical choices for new generation telescopes are indeed critical for maser science. **Team feedback with INAF support is fundamental**
(see e.g., 'SKA Memo 20-01' and 'VLBI20-30 …The future of the EVN')

To Giorgio and Nichi