Radio Astronomy at NWU®

NORTH-WEST UNIVERSITY
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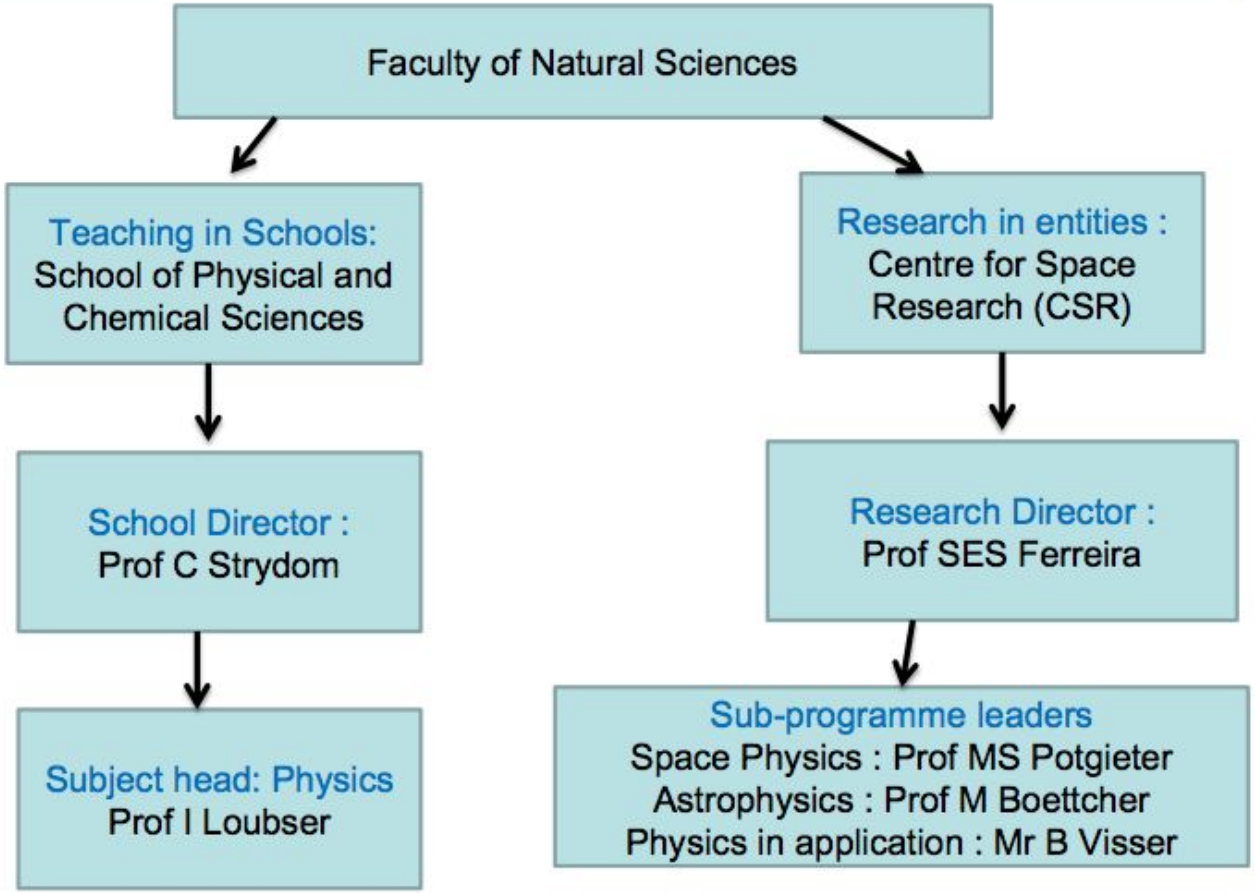
Maswanganye Jabulani Paul

DARA - Annual Network Meeting, Ekudeni Conference centre, South Africa 2-4 May 2018

To be a world-class research centre with excellent staff, students, post-doctoral fellows and support personnel, doing innovative, leading-edge research, both at the fundamental level and in applications, with sustainable funding.

Structure

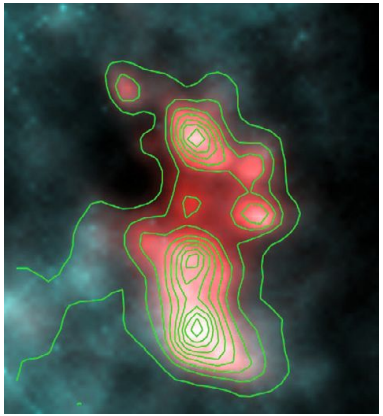

Faculty of Natural Sciences
Teaching in Schools:
School of Physical and Chemical Sciences
Research in entities :
Centre for Space Research (CSR)
School Director :
Prof C Strydom
Research Director :
Prof SES Ferreira
Subject head: Physics
Prof I Loubser
Sub-programme leaders
Space Physics : Prof MS Potgieter
Astrophysics : Prof M Boettcher
Physics in application : Mr B Visser

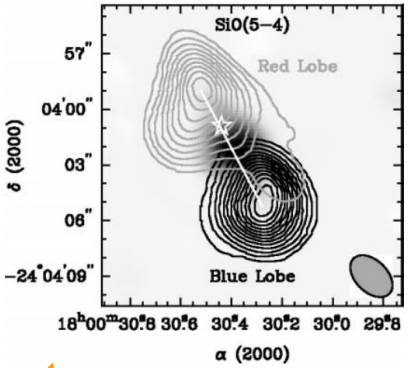
Centre of Space Research (Research Areas)

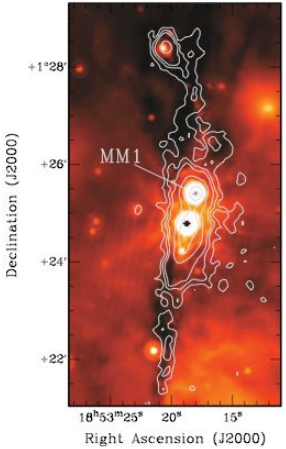
1. Heliospheric Physics
2. Antarctic Research
3. Gamma-ray Astronomy / High-energy Astrophysics
4. Physics in Application
5. Star-Formation and Radio-Astronomy

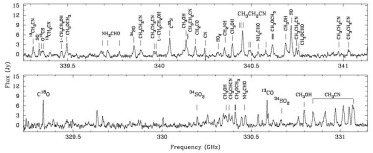
Our Research is in High-mass Star formation

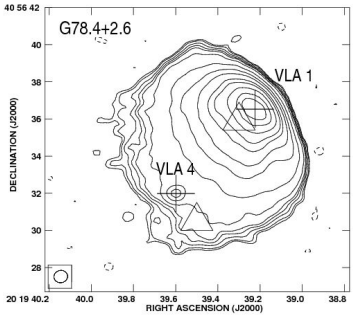
Observations: Evolutionary sequence



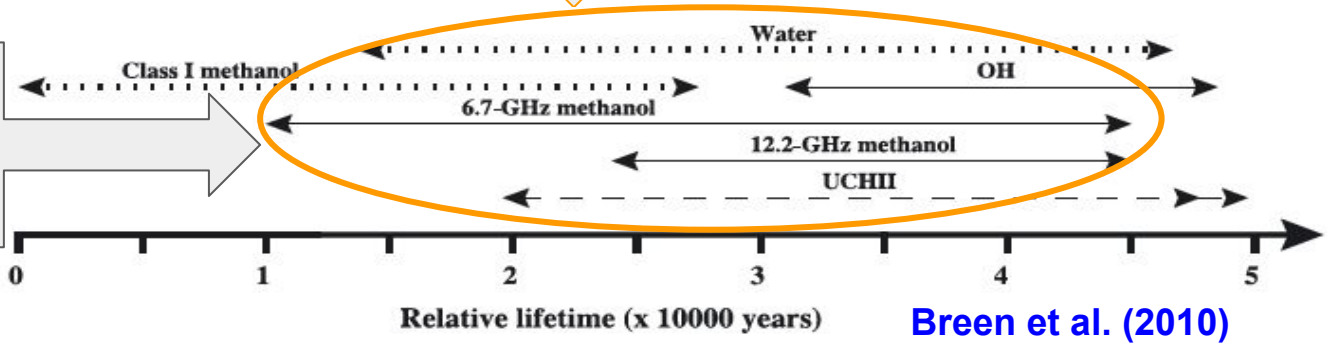








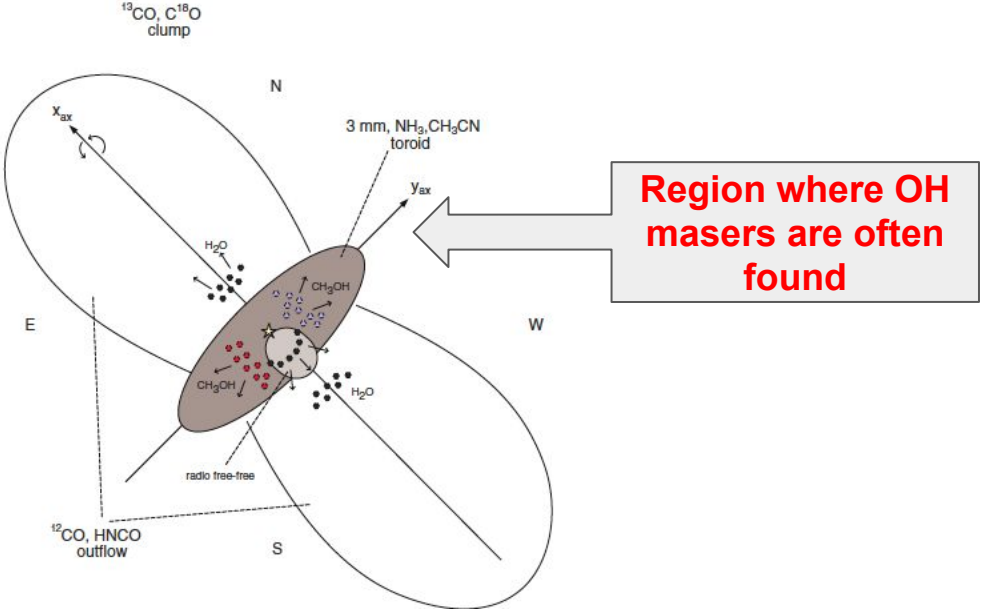
Region of interest



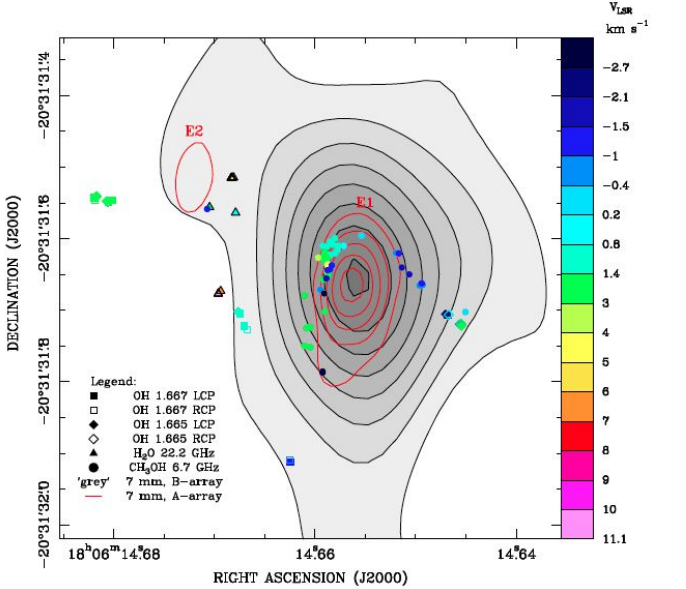
Breen et al. (2010)

Relative positions of maser species in high-mass star forming regions

So where are these maser species in relation to the high-mass protostar



Region where OH masers are often found



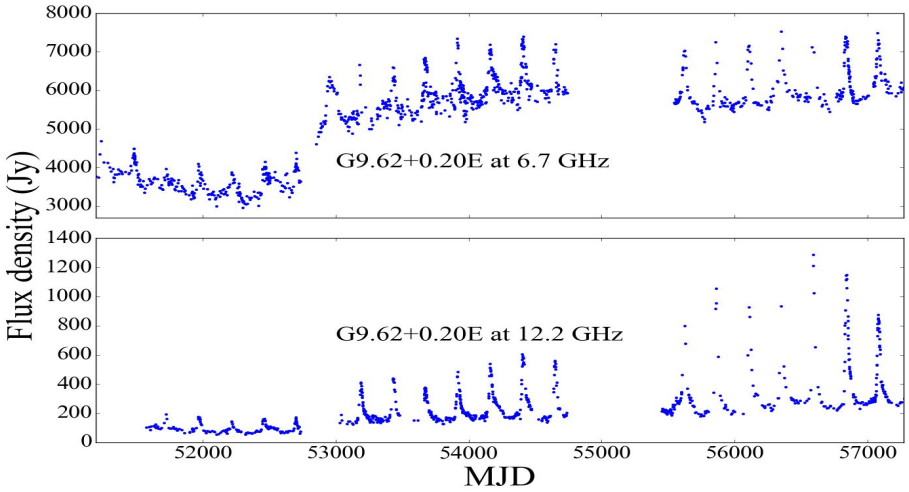
Sana et al., 2015

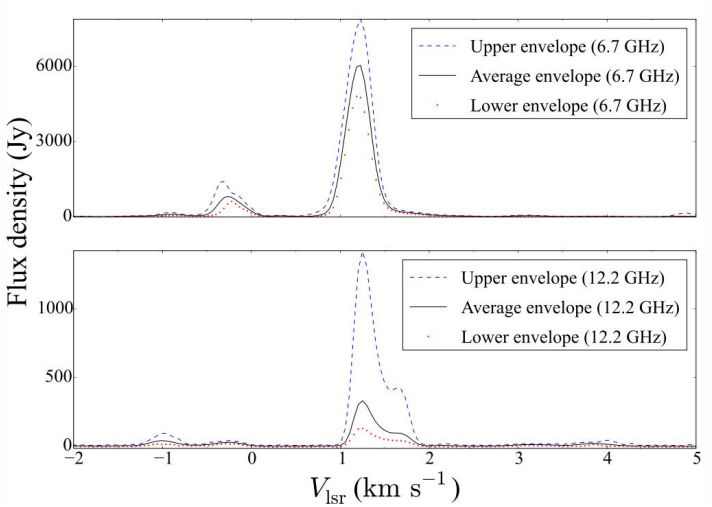
Sana et al., 2015

Our main drive: masers

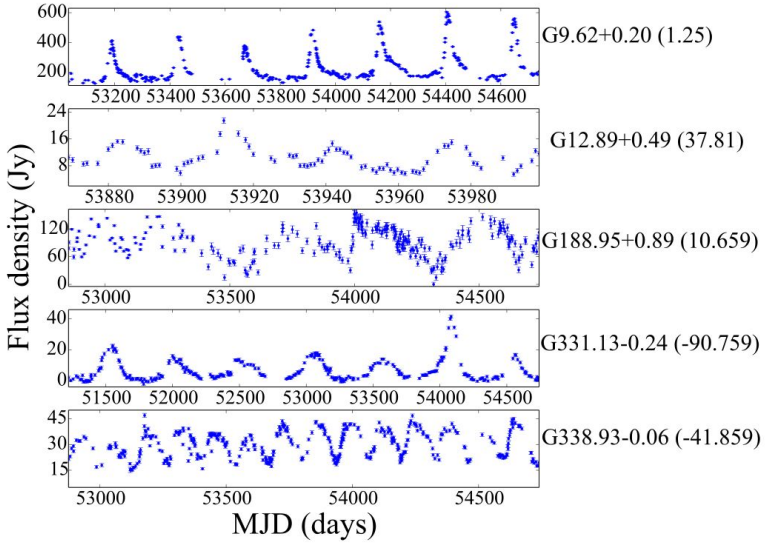
Goedhart et al. (2003,2004) reported periodic variability in seven of 54 monitored methanol maser at 6.7- GHz (at some cases together with 12.2-GHz) with the 26m HartRAO radio telescope.

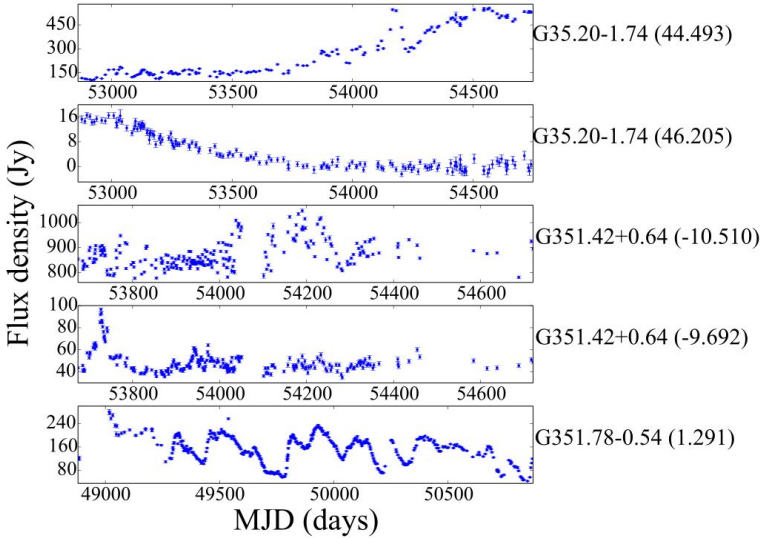
By 2014, three more sources from independent samples were reported by Araya et al. (2010), Szymczak et al. (2011) and Fujiswa et al. (2014) to show periodic variations.





Observed forms of methanol maser variabilities

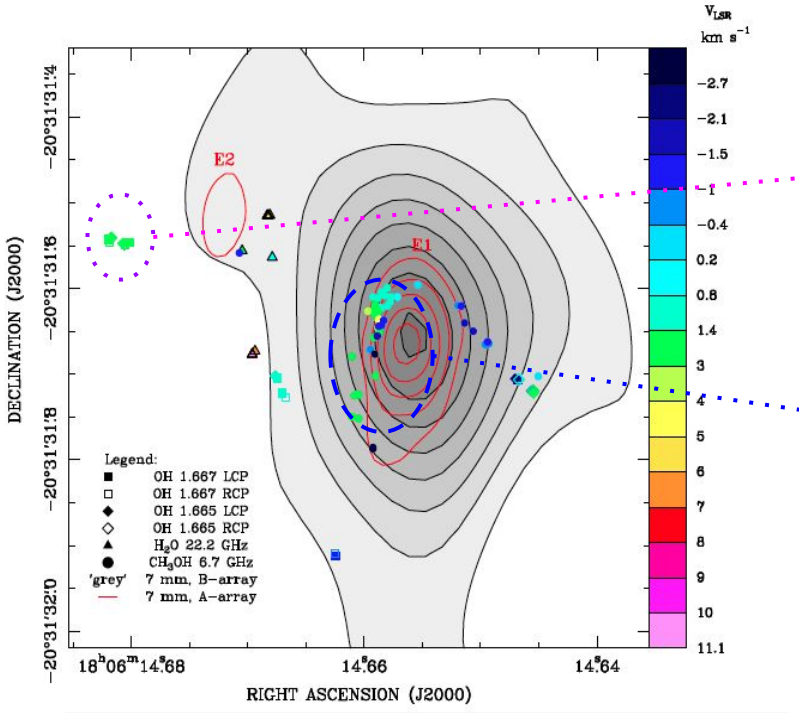




Periodic variable methanol masers, (Goedhart et al., 2013).
The determined period range is from 23.9 (Sugiyma et al., 2017) to 509 (Goedhart et al., 2013) days.

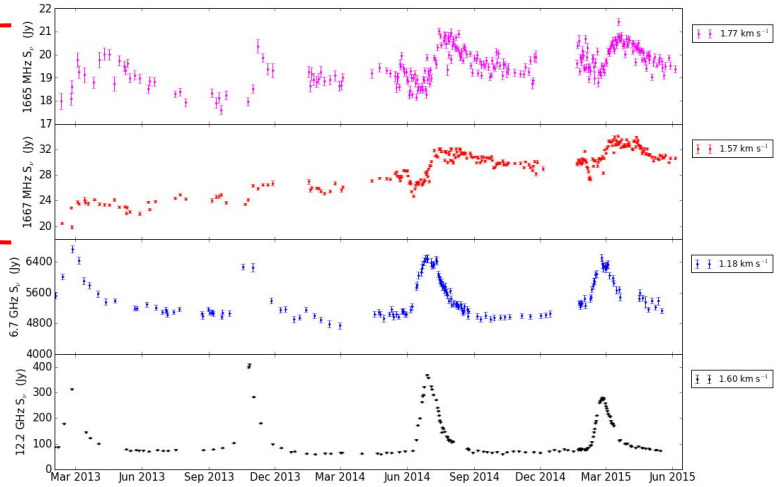
Irregularly varying methanol masers (Geodhart et al., 2009, MacLeod & Gaylard 1996, Maswanganye & Gaylard, 2012)

Monitoring Hydroxyl and Methanol masers in G9.62+0.20E



Sanna et al., 2015

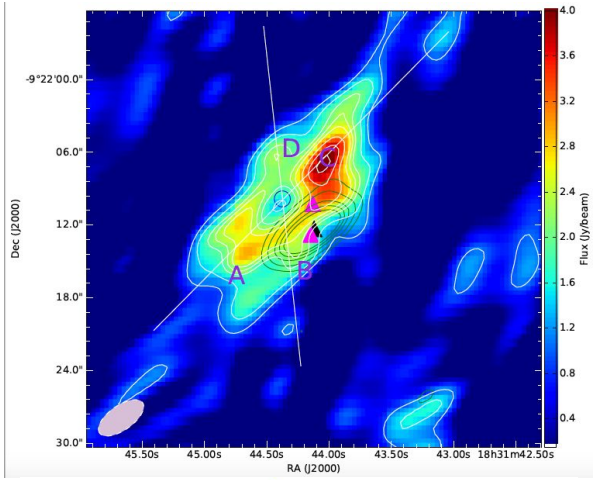
KAT7 radio telescope, Goedhart et al., (prep)

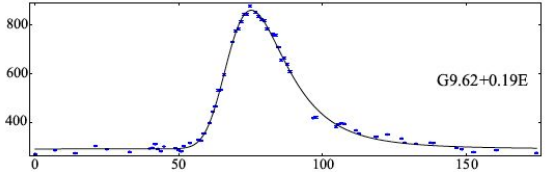


26m HartRAO radio telescope

More on simultaneous OH and Methanol masers monitoring programme (See. Mavis seidu's Poster)

^{13}CO (2-1) emission associated from different periodic maser light curves (Morgan et al., Prep)



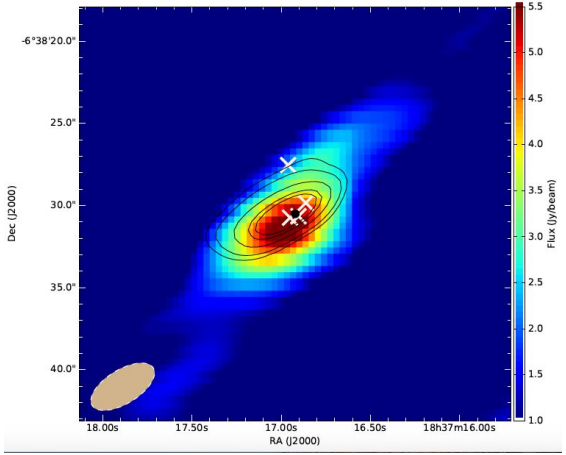


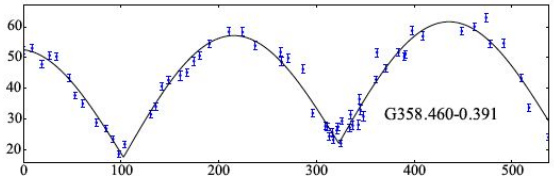
Observations were made with the The Submillimeter Array (SMA) configuration on the 27th of July 2016.

Left: Zero moment map for CO and dust continuum (black contour) in G22.357+0.066 (light curves are similar to G9.62+0.020E), with methanol (black dot) and water (black cross) masers.

Right: CO emission morphology, dust continuum (black contour), and maser (black dot) in G25.411+0.105 (light curve similar to G358.460-0.391)

Conclusion: These periodic methanol masers with different light curves have different signatures in CO emission.





What could be the origin of periodicity in methanol masers

Five postulation had been propose:

a). Changes in the seed photon flux owing to:

(i) Colliding wind binary (CWB) system (van der Walt, 2011,van der Walt, Goedhart & Gaylard, 2009)

(ii) Eclipsing binary companion in a proto-binary system (Maswanganye et al., 2015).

b). **Changes in dust temperature due to**

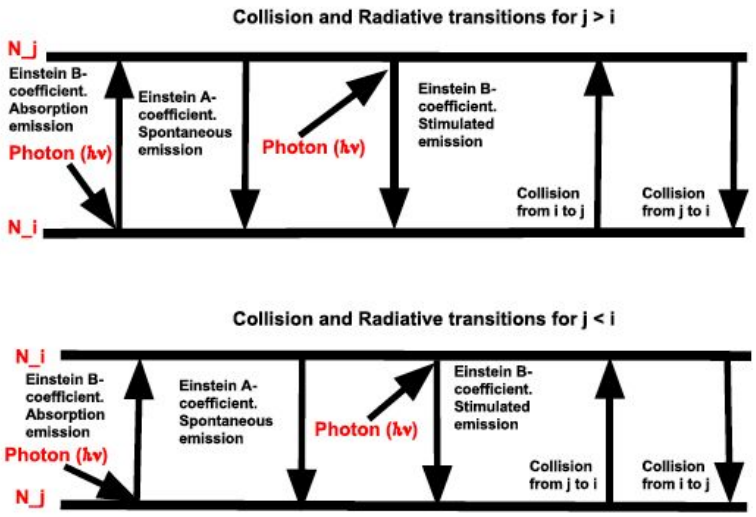
(iii) Rotating spiral shock in a proto-binary system (Parfenov & Sobolev, 2014)

(iv) Periodic accretion in a circumbinary system (Araya et al., 2010)

(v) pulsating high-mass Young Stellar Object (Inayoshi et al., 2013)

Maser Modelling: Statistical rate equations

Consider a 2-level molecule model.



A-Einstein coefficient of spontaneous emission

B-Einstein coefficient of absorption

Angle averaged intensity

$$\frac{\partial N_i}{\partial t} = A_{ji}N_j + (B_{ji}N_j - B_{ij}N_i)\,\bar{J}_{ij} + N_jC_{ji} - N_iC_{ij}$$

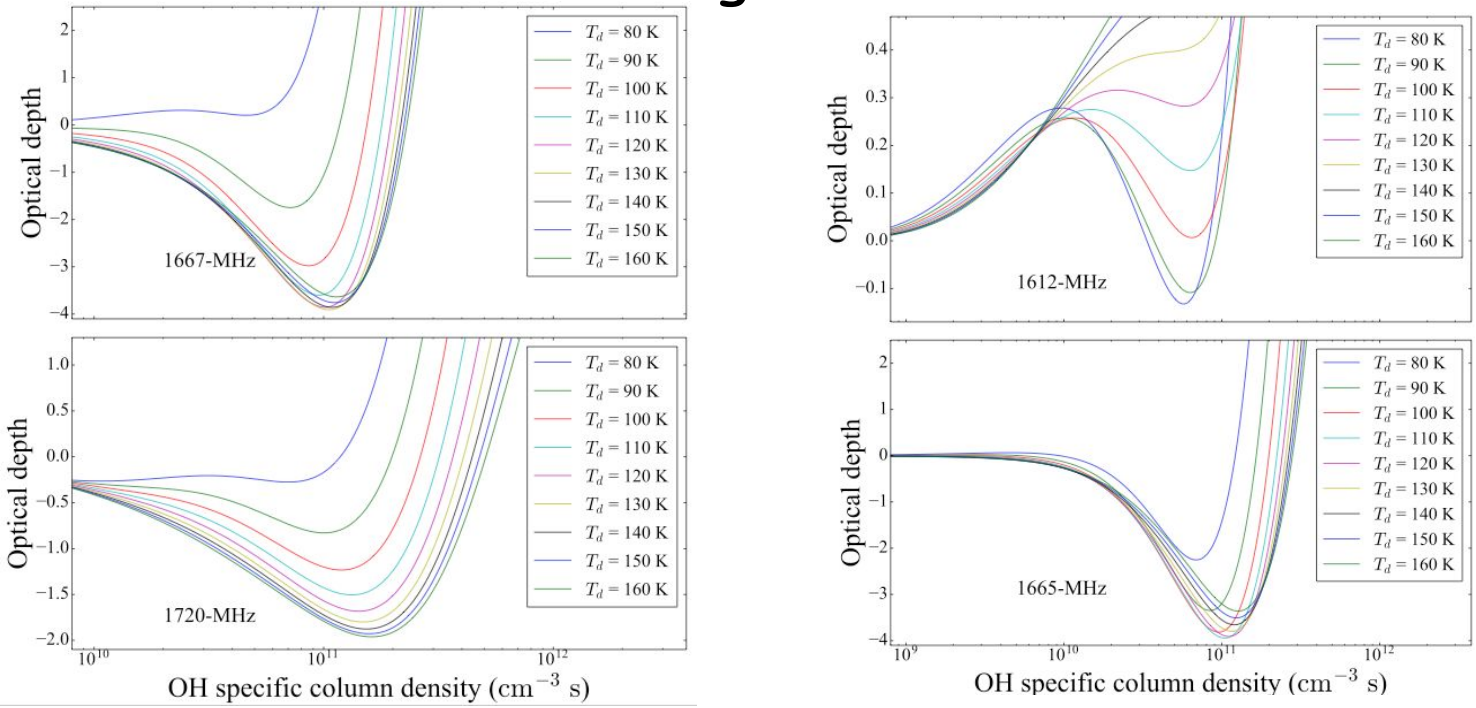
or

$$\frac{\partial N_i}{\partial t} = (B_{ji}N_j - B_{ij}N_i)\,\bar{J}_{ij} - A_{ij}N_i + N_jC_{ji} - N_iC_{ij},$$

B-Einstein coefficient of stimulated emission

Collision terms

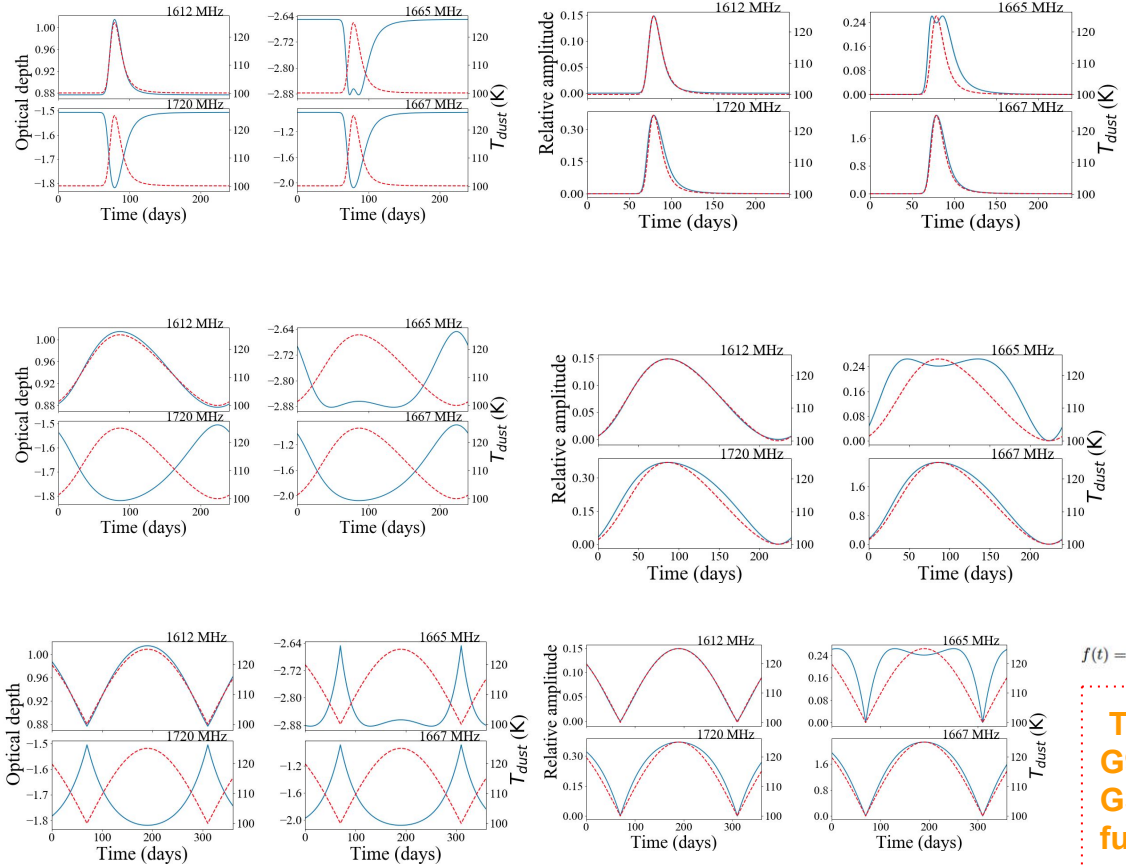
Searching for OH masers

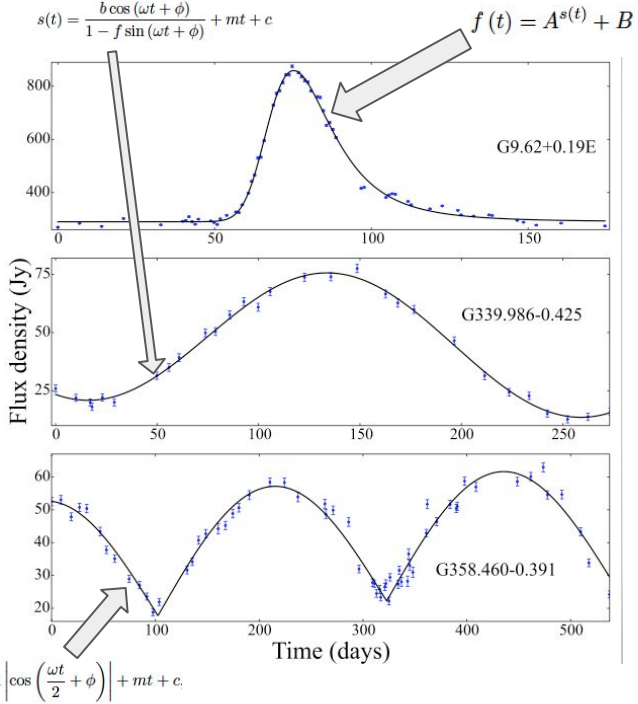


Behaviour of optical depth at different dust temperatures, for four ground state transitions.

Negative optical depths imply there is population inversion or a maser.
OH Mainlines - 1665- and 1667-MHz.
OH Setalitelines - 1612- and 1720-MHz.

Time-dependant OH maser modelling





The segmented light curves of the G9.62+0.19E, G339.986-0.425 and G358.460-0.391 maser fitted to the analytical functions, which are solid lines

Summary

Thus far, 17 methanol masers had been reported to show periodic variability and the origin of the periodicity is not known.

Therefore, we continue with our investigation of maser variabilities in high-mass star forming region by:

(1). Studying the molecular environment of periodic masers

(2). Searching for more periodic masers

(3). Monitoring other maser species, and

(4). Numerical modelling maser species

at North-West University.


Enkosi
Ngiyabonga
Amesege'nallo'
Zikomo Kwambiri
Siyabonga kakulu
Thank You
Asante sana
Ndatenda
Murakoze
N'itumezi
Masvita
Kea leboha
Zikomo