The Plan to detect MIR variability caused by pulsation of MYSO.

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Collaborator

- **Radio observation**
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- **Theoretical study**
  - K. Inayoshi (Kyoto Univ.)
  - T. Hosokawa (Tokyo Univ.)
  - K. E. I. Tanaka (Tohoku Univ.)

Outline

- Overview of MYSO evolution
  - How can we know inner condition of MYSO?
- Methanol maser emission near MYSO
  - General property of 6.7 GHz methanol maser
  - Periodic burst of maser
- The origin of periodic burst of maser
  - Stellar Pulsation model (Inayoshi+ submitted)
  - Missing key -infrared variability-
- The plan to detect MIR variability
  - Directly connect the protostar and the maser
  - Future observational plan using MIMIZUKU

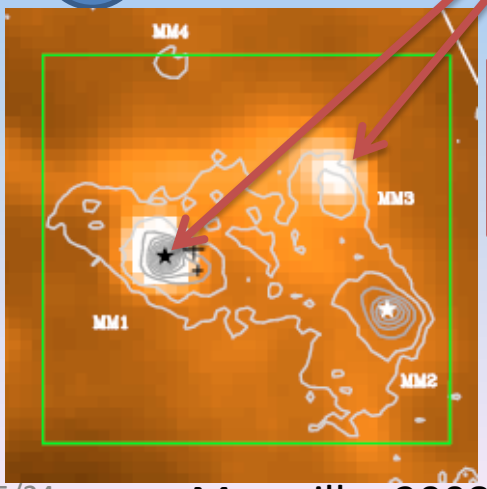
Brief view of MYSO evolution

Zero Age Main Sequence (ZAMS)

Star-less Molecular Core

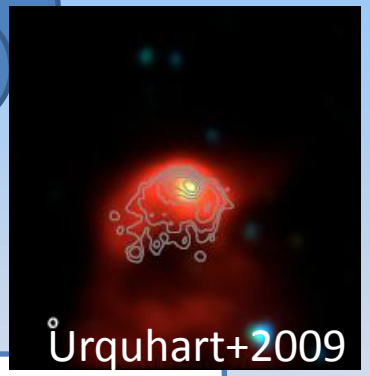
Massive Young Stellar Object (MYSO)

Ultra Compact HII region (UCHII)



Marseille+2008

Collapsing and internally heating



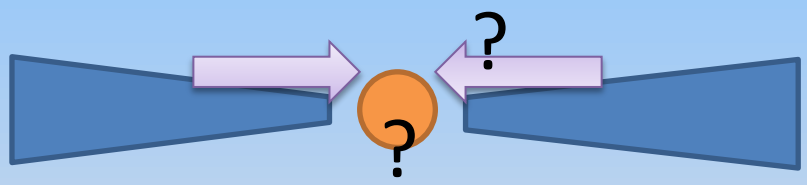
Urquhart+2009

Hydrogen burning begun and HII region is made and expanded.

Mass accretion in the MYSO stage

- High accretion rate is needed for overcoming radiation pressure feedback.
  - Typically ~10^{-3} $M_{\odot}$/yr is needed.
  - Accretion via optically thick disk enables this(?).

- Observational studies of accretion process and stellar inner condition is needed.
  - However, spatial resolution is not enough to search disk at near MYSO (<1000AU).



They are far from us!!

Maser emission near MYSO

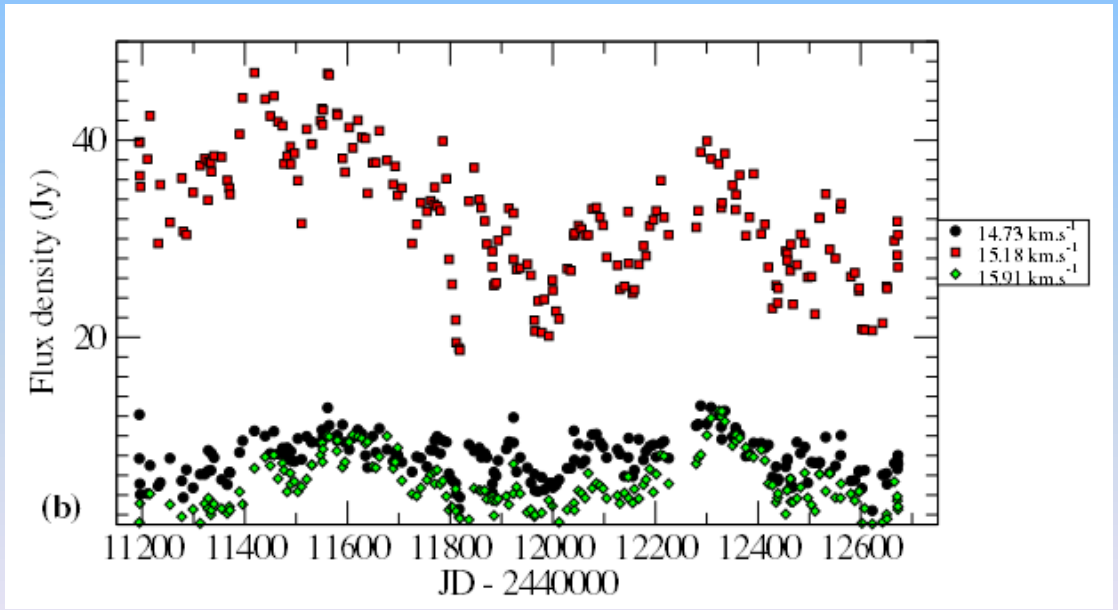
- Typically, there are several kinds of masers near MYSO.
  - They are tracer of the MYSO.

- The famous 6.7 GHz methanol maser emission
  - Thought to be associated with circumstellar disks around forming massive stars (Sanna+2010).
  - Radiatively pumped by infrared emission of warm dusts in disks (~ 150 K; Cragg et al. 2005)

Periodic burst of methanol maser

- Recently, periodic flux variations of methanol masers over several 10-100 days were reported (Goedhart+2004,2009)

This suggests the luminosity variation of nearby forming massive stars or accretion disks.



G196.45-1.68(Goedhart+2004)

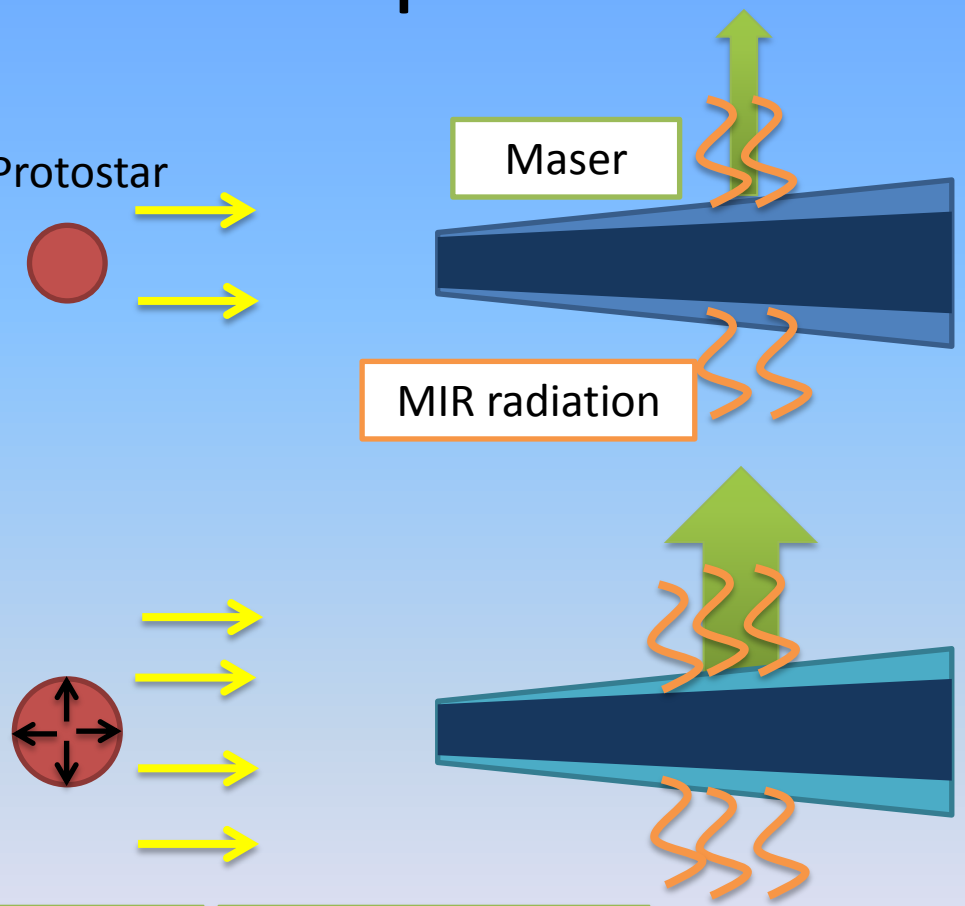
The origin of flux variability of maser

- Colliding-wind binary (van der Walt 2011)?
- Periodic accretion onto binary systems (Araya et al. 2010)?
  - They cannot explain there are no variable masers whose periods are shorter than 10 days.

- **"The pulsation of protostars growing via rapid mass accretion" most likely answer this. (Inayoshi+ submitted)**

The mechanism of flux variability of maser via the stellar pulsation

Protostars growing via rapid mass accretion become ***pusational instable*** at a certain phase in accretion.



①Protostar becomes brighter via pulsation

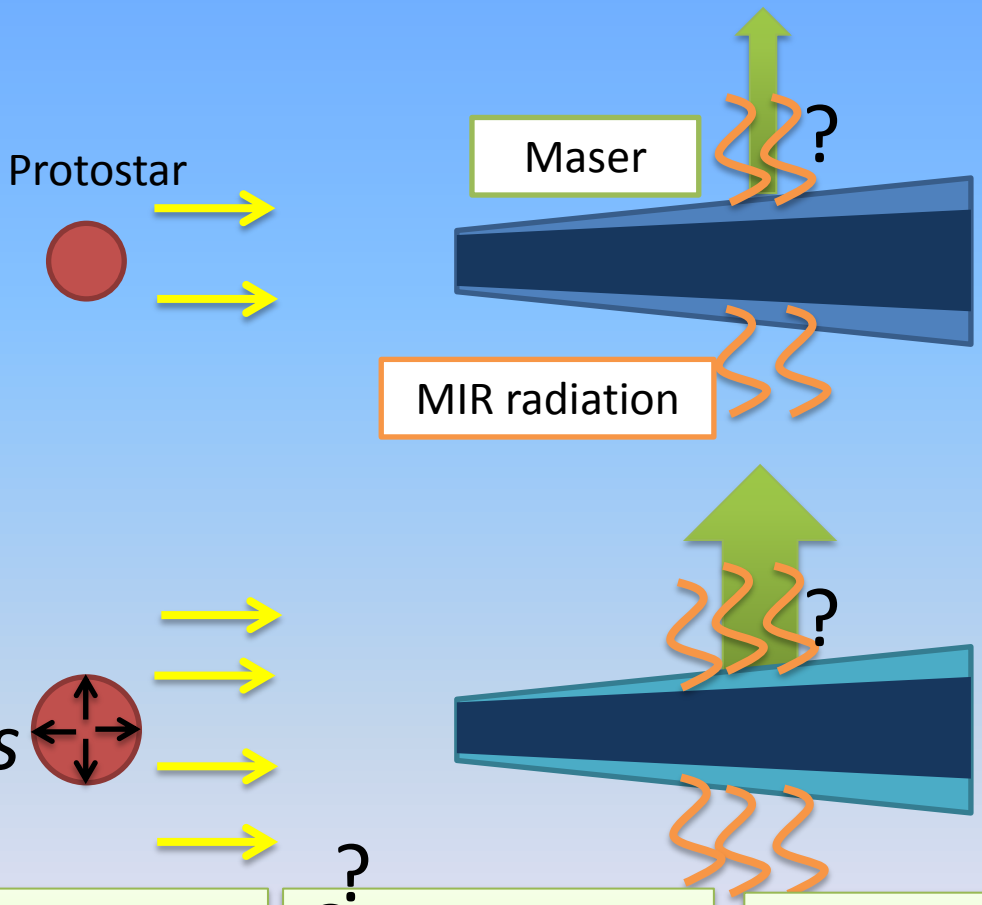
②Disk gets warmer and emits much MIR radiation

③Strong MIR radiation makes masers brighter

The Missing Key

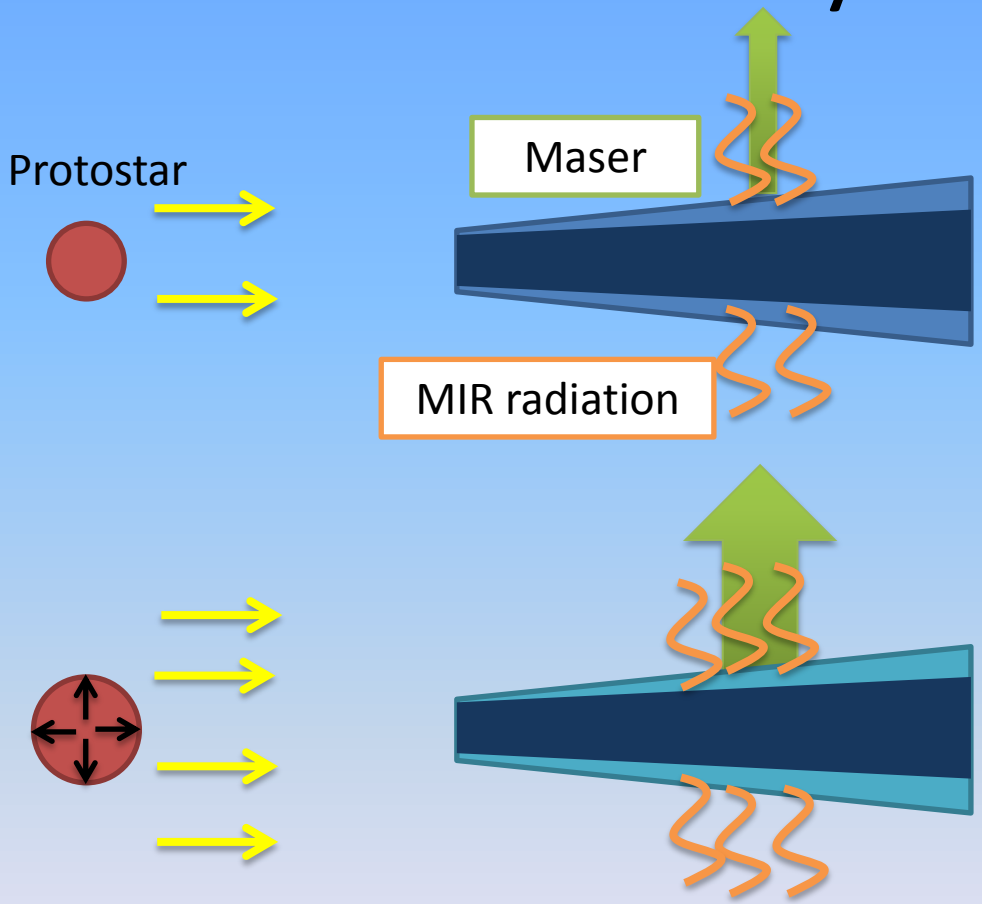
However, there is a lack of observational verification.

To begin with, there is no infrared observational supports of maser mechanism!



The answer
-The plan to detect MIR variability-

- If the pulsational model is *true*, MIR flux from disk *varies with* maser flux variation.
  - *We can also test the maser mechanism with this observation*



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Directly connect the protostar and the maser

- Simultaneous monitoring in the radio and the MIR is essential for test this theory.
- If MIR variability is detected, observational support of the model is given for the first time.
  - Observations also give the detail physical parameters of pulsation and thus give us inner condition of MYSO.
  - It also proves that masers are pumped by infrared radiation from disks.
- If not, either the model or maser mechanism is denied!

How to detect it?

- To detect it, however, MIR observation does not have good accuracy in flux measuring.
  - No space telescope is available until 2018.
  - Ground MIR observing instruments suffers from first variability of background sky flux.
    - Only ~10% accuracy is achieved at present.

Overcoming methods are essentially needed!

Overcoming method
Radical improvement with MIMIZUKU

- Developing MIR observing instrument MIMIZUKU achieves ~1% accuracy of flux measuring!

- It is enough to detect the

MIR variability.

  – Disk temperature varies

  ~ a few * 10 K.

Summary

- Resent study of maser flux measuring shows the periodic variability.
  - The stellar pulsation may cause it.
- MIR monitoring is essential for verification.
  - Giving direct connection between star and maser.

- In future, MIMIZUKU will solve this question completely.