IR Variability, Maser Activity & Protostellar Accretion

B. Stecklum (TLS)

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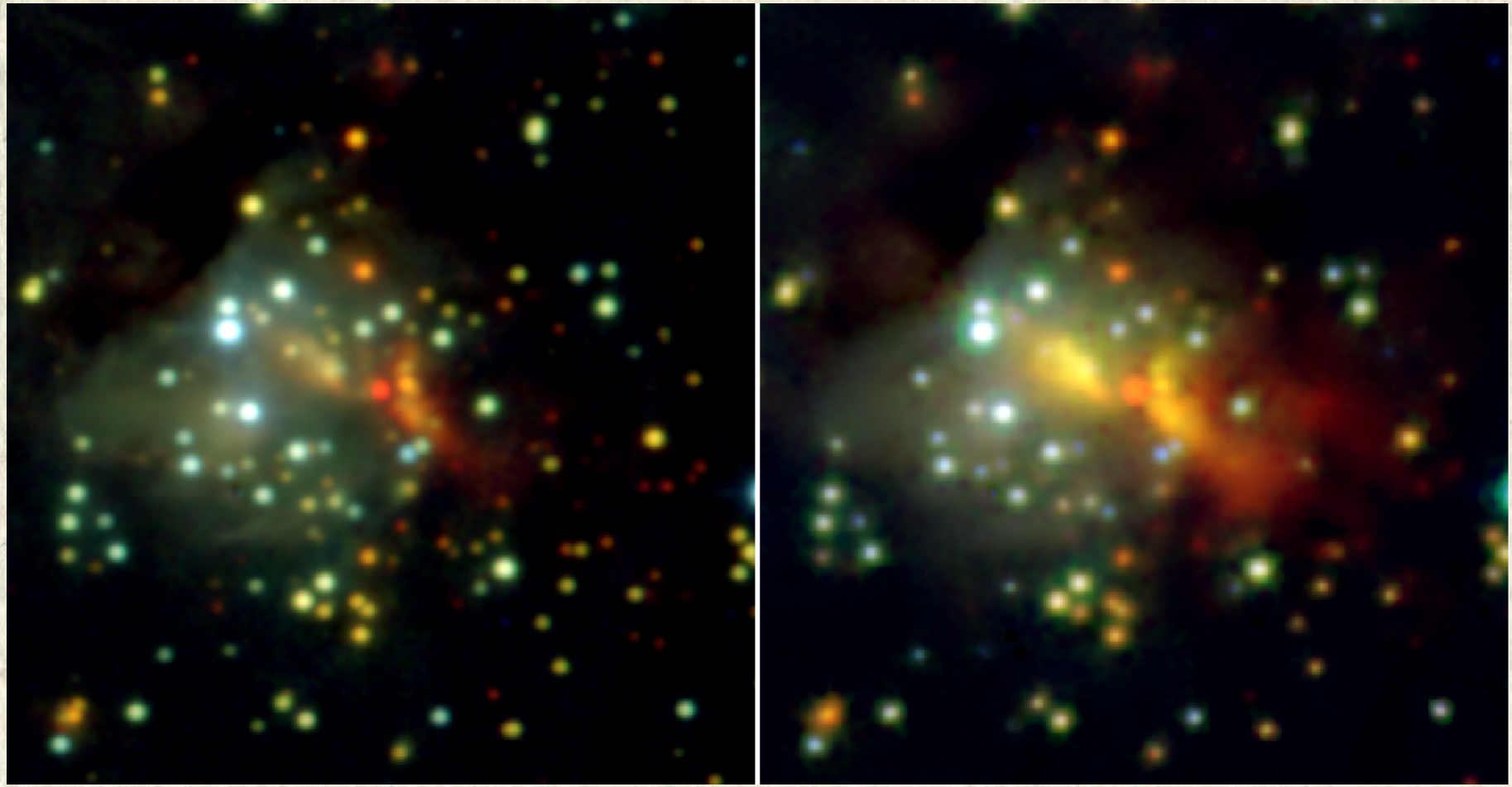
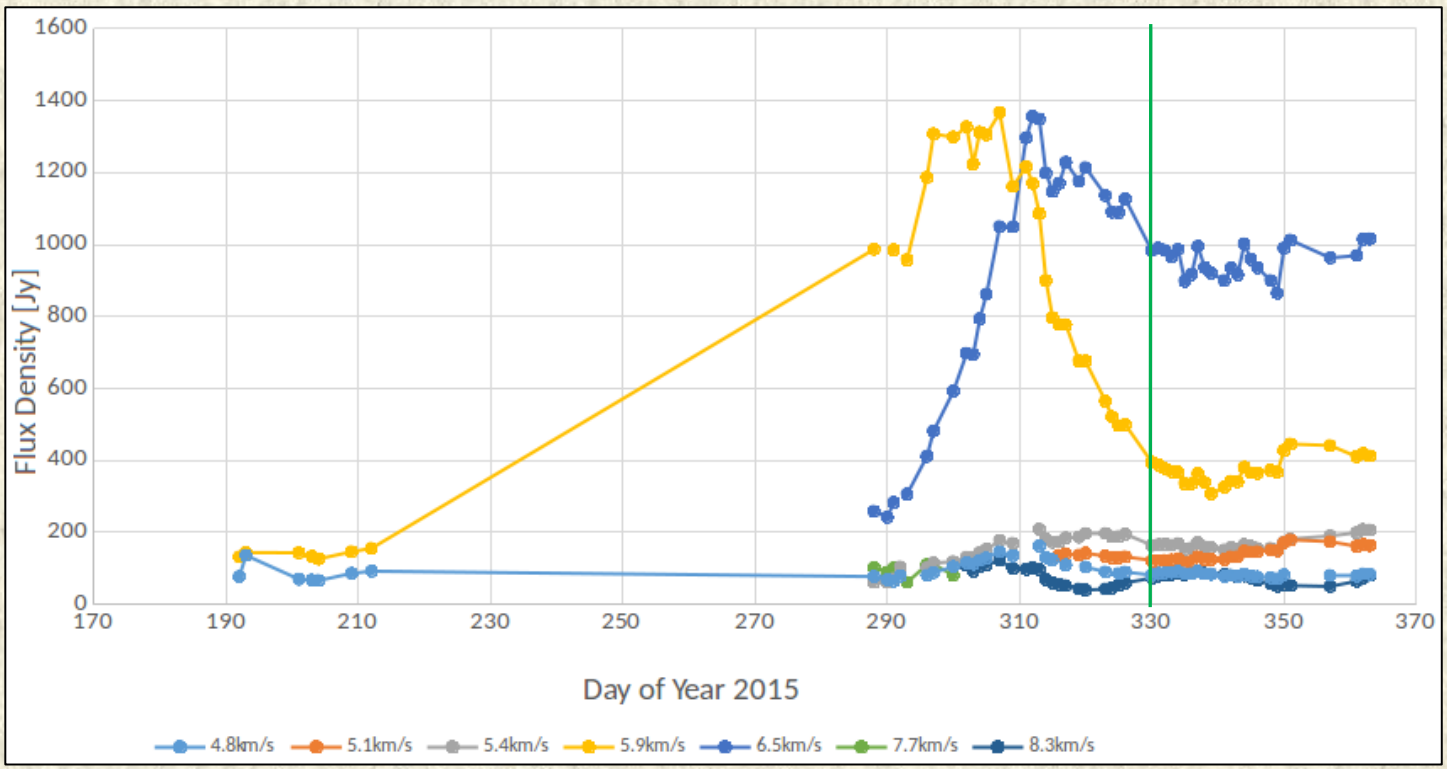


S255IR-NIRS3 – the first HMYSO accretion burst (Stecklum+ 2016, Caratti o Garatti+ 2016)

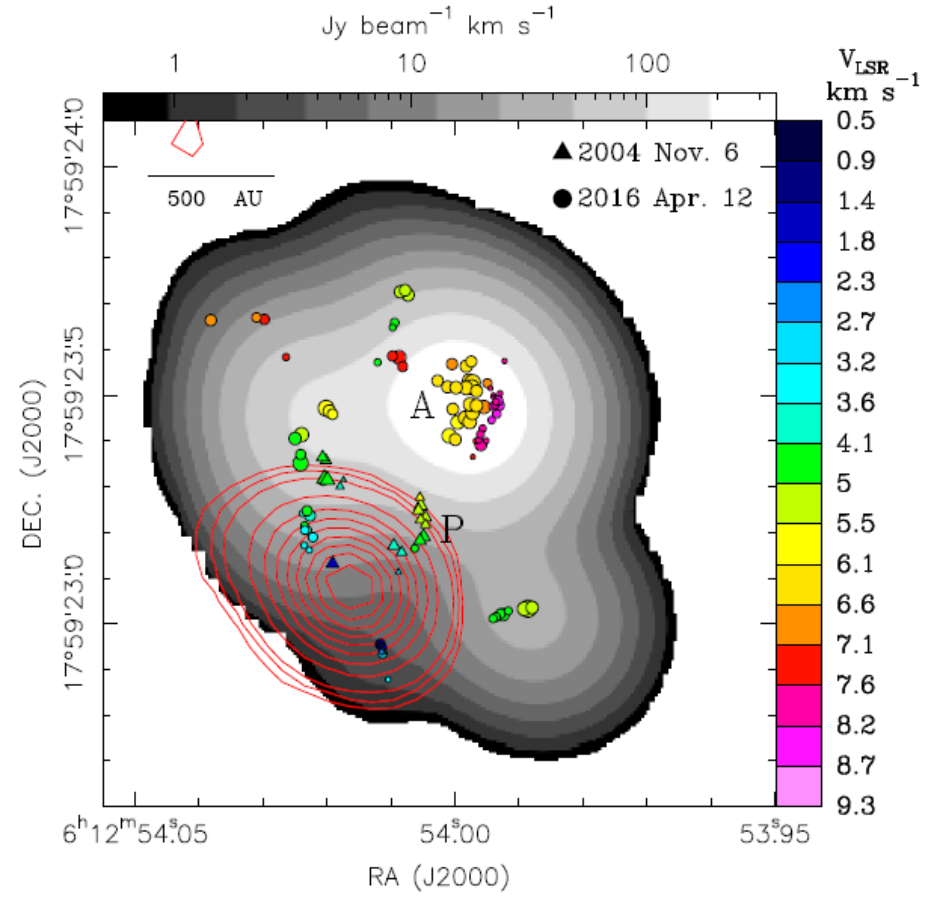
A Ringing Bell – The Methanol Maser Flare of S255IR

Class II 6.7 GHz methanol masers, thought to be pumped by thermal IR emission (Sobolev+ 1997), trace embedded luminous YSOs (Breen+ 2013). They are generally variable, and some show regular flux changes (Goedhart+ 2014, Szymczak+ 2015). The methanol maser in S255IR was detected by Menten (1991).

CH_3OH maser flux variation showing the **flare** of the **5.9km/s** component and the **emergence** of a new one at **6.2 km/s** (Fujisawa+ 2015). The vertical line marks the date of our first NIR imaging. The drop of **5.9km/s** component is probably caused by photodissociation (Moscadelli+ 2017). See poster #5 for recent monitoring.



A Ringing Bell – The Methanol Maser Flare of S255IR



Distribution of the 6.7 GHz CH_3OH masers toward NIRS3. Triangles and circles represent maser spots before and after the outburst, respectively. The gray-scale image shows the velocity-integrated emission of the 6.7 GHz masers. The JVLA 5 GHz continuum emission is drawn with red contours (from Moscadelli+ 2017).

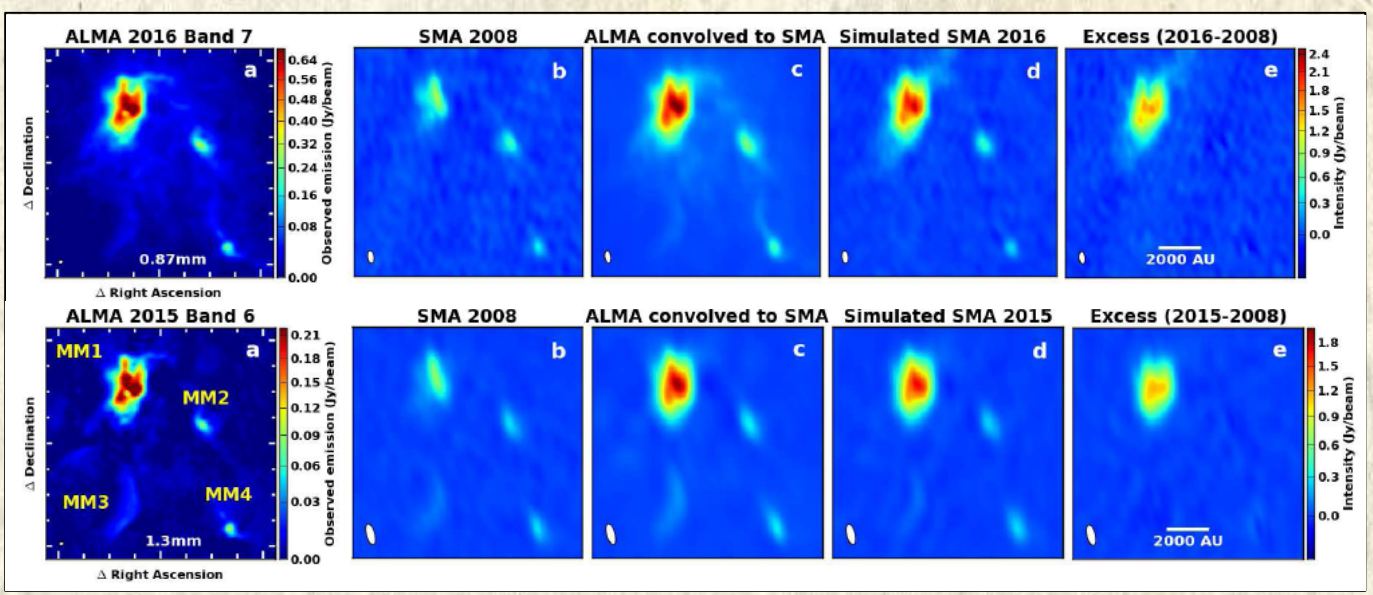
The spatial separation of the maser clusters and the delay between the flares of old and new components indicate a speed of the excitation wave much less than c.

- Substantial optical depth
- Increased heat capacity due to grain growth
- Sublimation of grain mantle volatiles
- The small difference in radial velocity is inconsistent with all masers residing at the tangential points of the disk

The NGC6334I-MM1 submm/mm Burst

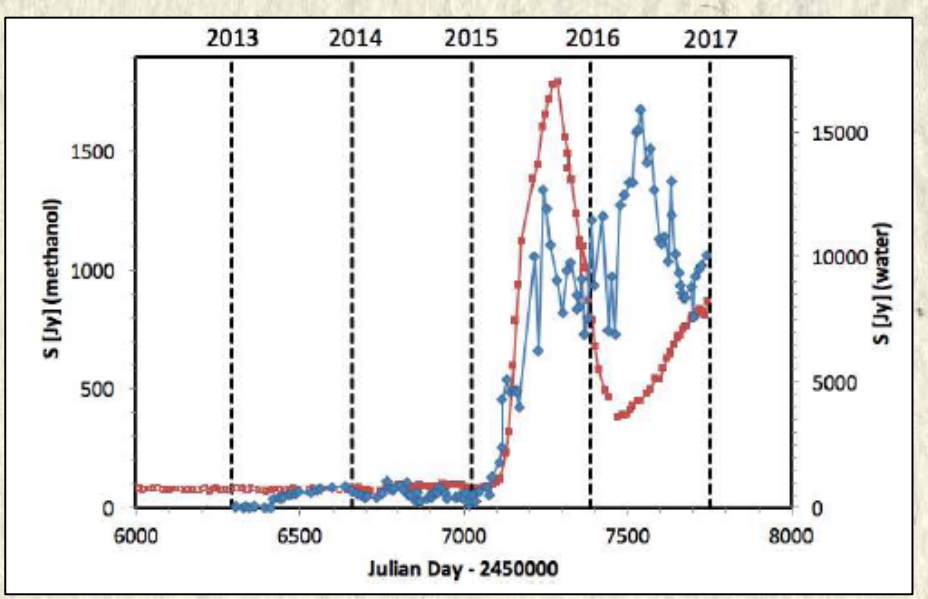
Talks by T. Hunter and C. Brogan on Thursday

SMA and ALMA 0.87 mm and 1.3 mm maps reveal the burst of NGC6334I-MM1 (Hunter+ 2017)



The burst is accompanied by 6.3 GHz CH_3OH (red) and 22 GHz H_2O (blue) maser flares.

YSO accretion bursts trigger maser flares by releasing molecules frozen onto grains to the gas phase and providing stronger IR pumping radiation.



Disclosing the Mystery of Periodic Masers

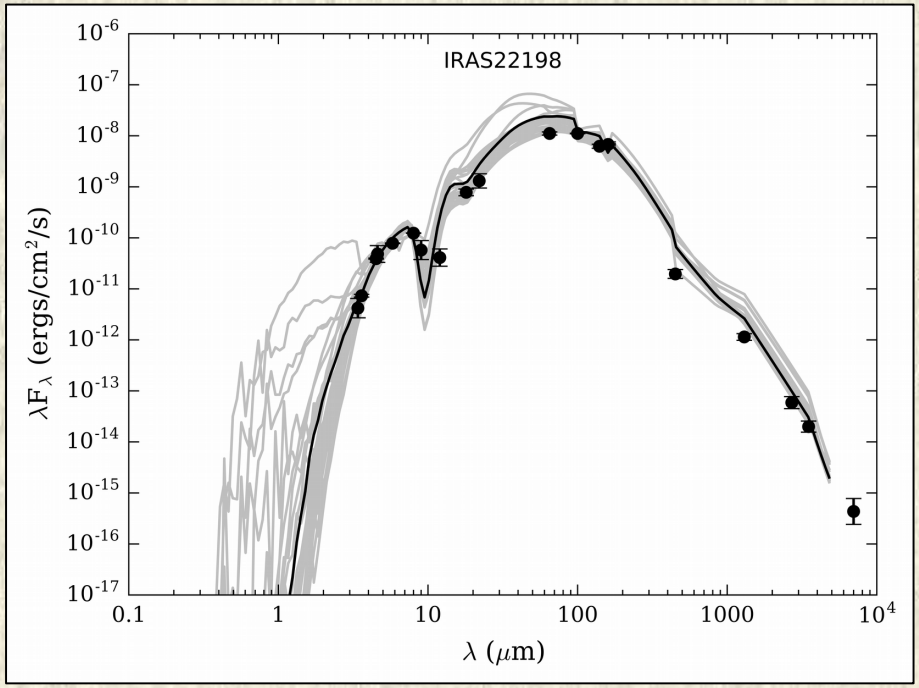
There are several models for periodic masers to reproduce their basic temporal behavior:

- Variable background free-free radiation due to colliding binary winds (van der Walt, 2011)
- Variable IR pumping caused by protostellar pulsations (Inayoshi+ 2013, Sanna+ 2015)
- Variable IR pumping from binary bow shock heating (Parfenov & Sobolev 2014)
- Superradiation from large-scale entangled quantum mechanical states (Rajabi & Houde 2017)

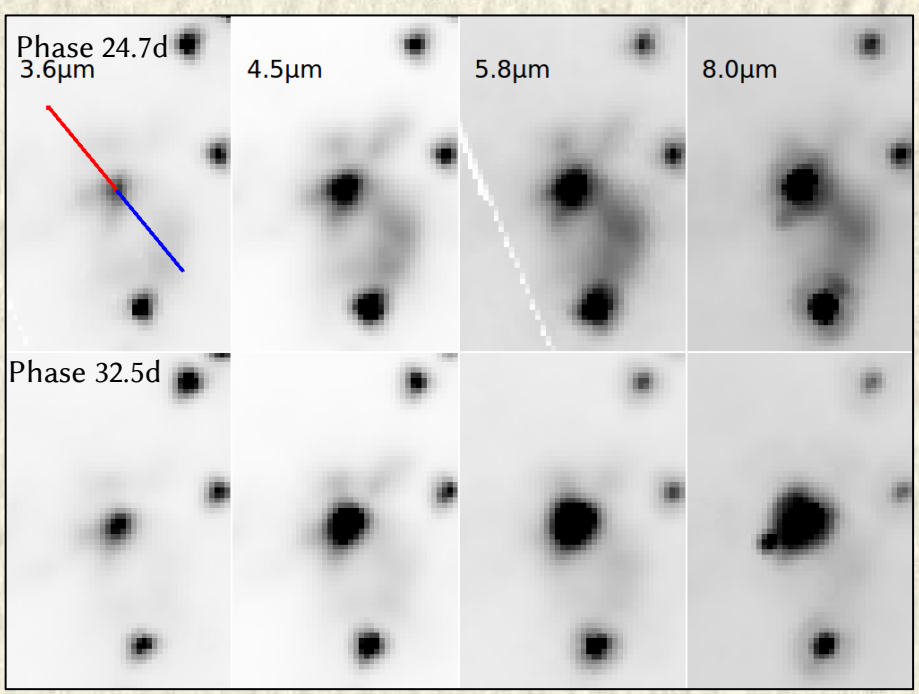
The observed flares due to HMYSO accretion bursts suggest that periodic changes of the accretion luminosity, possibly caused by an eccentric binary component (Artymowicz & Lubov 1996), may lead maser periodicity. In order to verify this idea we scrutinized the available space-based imagery of YSOs associated with periodic masers which yielded one light curve.

The Case of G107.298+5.639

Intermediate-mass YSO (Sánchez-Monge+ 2010) located at 764±27pc (Hirota+ 2008) associated with 6.7GHz CH_3OH and 22GHz H_2O masers showing a periodicity of ~34.6d (Fujisawa+ 2014, Szymczak+ 2017).

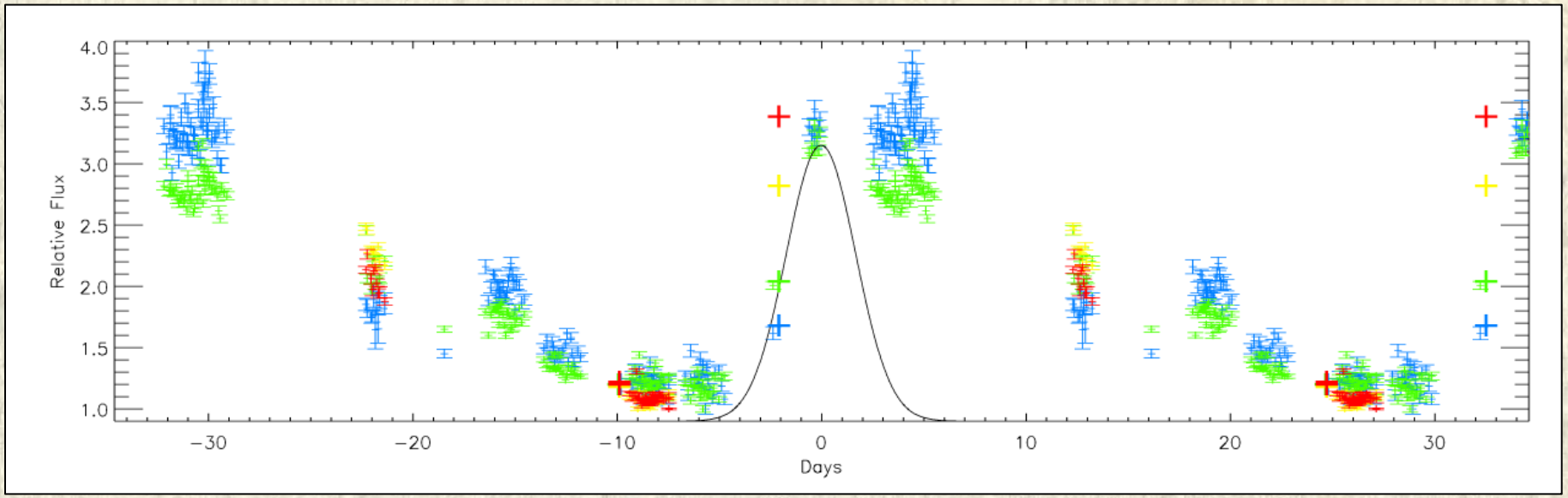


SED (symbols) and 30 best radiative transfer models obtained with HYPERION (Robitaille 2011, 2017). The black line shows the best fit while the others are displayed in gray.



SPITZER/IRAC images of G107 (center) for two epochs. The sense and position angle of the bipolar outflow are indicated. The out of phase brightening of the YSO and the blue-shifted outflow lobe is due to the light echo from the latter.

The Case of G107.298+5.639



NEOWISE multi-color (W1, W2, W3, W4) light curve of G107, folded by the 34.6 d period, and normalized to the low state. The solid line represents the fit to the maser light curve (Fujisawa+ 2014). Large crosses mark IRAC values. Jumps at phase of ~4 d are due to long-term trends.

- G107 is the first YSO for which a relationship between the maser periodicity and the IR variability could be established.
- While the shape of the light curve resembles that of Cepheids, the source does not fit the luminosity-period relation of Inayoshi+ (2013).
- The asymmetric IR light curve is inconsistent with the eccentric binary accretion model.
- Our present NIR/radio observing run aims at deriving the phase lag, which requires to account for the light echo.