3D Models of Maser Flares

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Rough Guide to Flares

- No precise definition
- Many types of variability
- Some periodic (P=26 to several x 100d)
- \( \frac{F(\text{flare})}{F(\text{quiescent})} = \) a few to apparently \( \infty \)
- May involve several species/translations with (anti-)correlation
Locations in W75N
Conclusions for W75N

- Flaring in H2O and OH
- OH main lines and 1720MHz flares not coupled by shock (maybe by IR ~5 light days)
- 1720MHz flares more associated with H2O
- 1720 flare spots have large B (20mG)
- “ “ “ “ “ “ proper motion
- F(flare)/F(quiescent) ~ 100 for 1720MHz OH and for H2O
- Not periodic; 1720-MHz decay time ~120d
Investigation of Mechanisms

- Rotation of aspherical 'clouds'
- Superimposition of clouds in line of sight
- Variability in the seed radiation
- Variability in the pumping radiation
- Shock compression of a cloud (not yet)
- Others...please suggest!!
Overview of Model

- Code fully 3D
- Includes saturation
- Uniform clouds (restriction removed)
- CVR
- Phenomenological pump
- Unpolarized (restriction removed)
Rotation of Spheroidal Clouds

- Can get contrast of hundreds
- Duty cycle 0.2-0.5
- Contrast up, Dc down with increased saturation and/or more distorted cloud
- Periodicity unlikely (cloud stability)
Superimposition

- Can get flare times of months for AU-scale clouds
- Duty cycle may be <0.1
- Easy to get flux ratio in thousands
- Real systems not periodic
Superimposition Movie

2 Clouds | Initial Nodes per Cloud: 150 | Depth: 6.0 | Inclination Angle: (0)(π/250)

Observer's Perspective

Observed Radiation Intensity

Observer Position
Variation of Seed Radiation

- Qualitatively different behaviour: high duty cycle
- Models similar when saturated, even for different backgrounds
- Candidates: G338.92-0.06 & G351.78-0.54 in Goedhart et al. '04
- Can be periodic
Variation of Pump

- Distinct flaring response to sinusoidal input
- Amplitude and duty cycle similar to rotation but shorter times scales available
- May be periodic
- Also tested sinusoid in log: more extreme
Pump Movies
Towards a Period/Duty Cycle Plot

- Duty Cycle
  - <100 x light-crossing time for 10AU cloud
  - Optical depth effects in pump lines and/or continuum
  - Need explicit time derivative
  - Variable pump
    - Flux ratio: few to hundreds
  - Variable background
    - Flux ratio: few to tens
  - Nothing yet
  - Line of sight overlap
    - Flux ratio: thousands
  - Rotating clouds
    - Flux ratio: few to hundreds
Conclusions

- All the mechanisms tested can produce variability that is arguably 'flaring'.
- The most extreme flare to quiescent flux ratios come from line of sight superimposition.
- As above for smallest duty cycles (at least if pump variation is ~sinusoidal).
- Variation of seed radiation causes a quantitatively different behaviour ('anti-flare').
- Shock compression flare to be done: needs hydrodynamic solutions.