Star Formation & The Galactic Center

Mark Reid
Harvard-Smithsonian CfA
Massive Star Formation

- Solar-mass star formation paradigm: accretion disk
  Still not critically tested

- Massive star formation:
  No paradigm yet
  Coalescence possible

HST: Orion Nebula “Proplyd”
IR & Radio

• Orion-I (IRc2):
  Dominant massive star in KL region

• Obscuration problem:
  $A_v \sim 100$’s to 1000’s
  $A_{IR} \sim 10$’s to 100’s

Need radio waves to see inside

Menten & Reid (1995)
Orion-I

- VLA continuum image
  
  43 GHz (7mm)

  40 mas = 20 AU resolution

- VLBA line image

  SiO masers

  0.5 mas = 0.25 AU resolution

Greenhill, Reid, Menten & Chandler
Disk Geometry

Massive star protostellar “disk”: resolved by VLA
Seeing material expelled from disk (rotating outflow)
EVLA Contributions

- **EVLA-I**: increased sensitivity (x 10)
  
  Current image barely detected; increased sensitivity will allow studying details (e.g., disk thickness, disk truncation, jet formation, etc.)

  Move from studying nearest source to many others, e.g., in Cep A, NGC 6334, W3, etc.

- **EVLA-II**: increased angular resolution (x 10)
  
  Resolve internal structures: e.g., gaps, density distribution
Galactic Center

Radio

Sgr A*

10 arcsec ~ 1 l.y.

Infrared

VLT / NACO 1.6-3.5 microns

VLA: 1 cm (Zhao)

January 10, 2006 AAS EVLA Town Hall Meeting
Radio/IR Astrometry

Grid of stars visible in IR and Radio

Red Giant stars with SiO masers:

Radio frame “perfect”

Reid & Menten (2003)
Where is Sgr A*?

1995

Menten, Reid, Eckart & Genzel (1997)

2002

Reid et al (2003)
Stellar Orbits

- Limited by distortions across IR frame
  Requires grid of reference stars to remove systematic errors
  Need < 1 mas accuracy
- Deviation from elliptical orbits give
  Extended dark matter
  Stellar remnant graveyard
  Effects of BH spin (precession)
- G.C. distance: $R_0$ (<1% unc.)
  Galaxy rotation speed (<1% unc.)
  Recalibrate EG distance scale

Credit: Ghez & Tanner
EVLA Contributions

• EVLA-I: Super correlator (x 12 speed-up)
  Observe all stars (+/- 400 km/s) simultaneously;
  currently requires >12 bands observed sequentially
  Increased sensitivity => more stars, <1 mas positions

• EVLA-II: increased angular resolution (x 10)
  Increase astrometric accuracy from <1 mas to <0.1 mas