Distances to methanol masers

EVN programme of phase referencing at 6.7GHz

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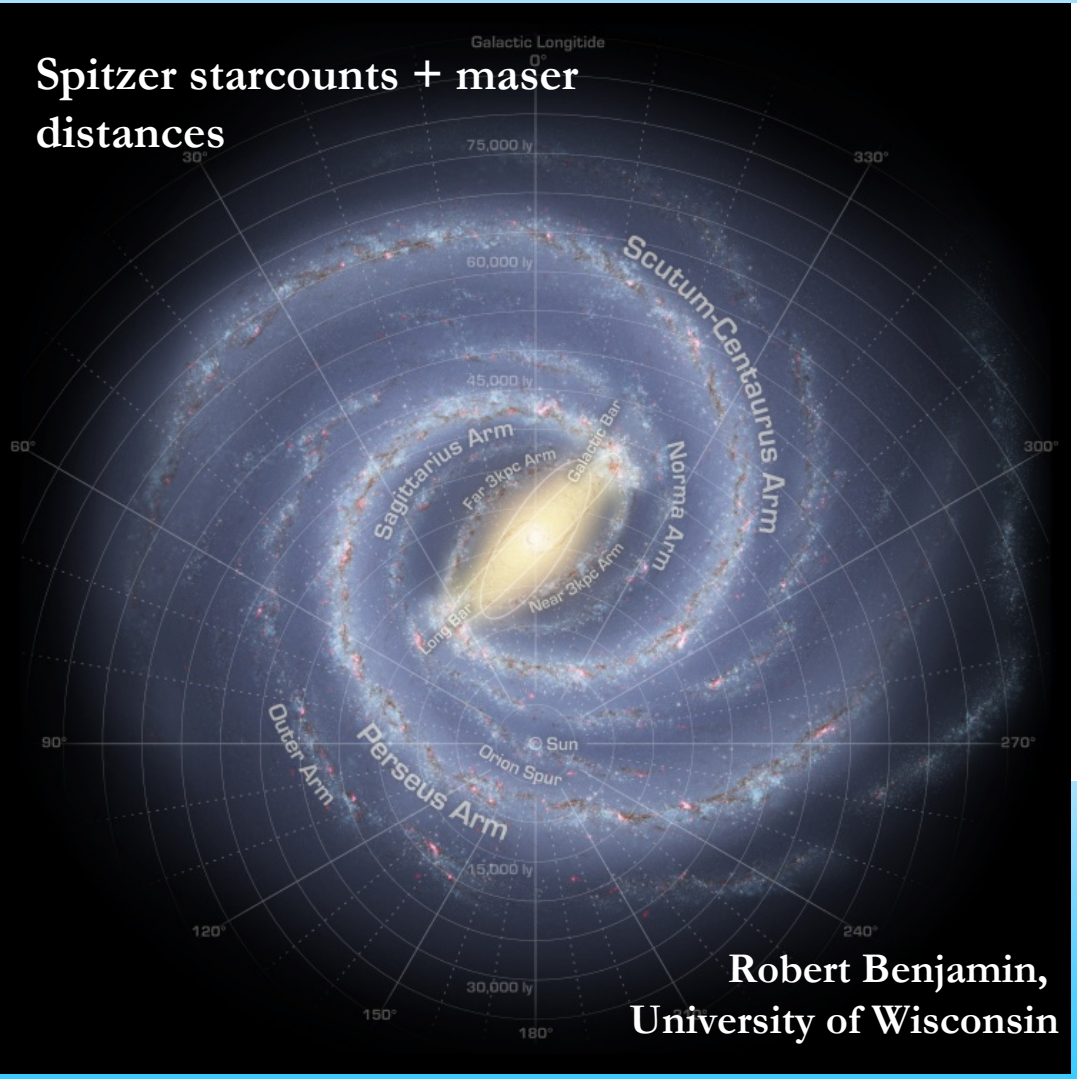
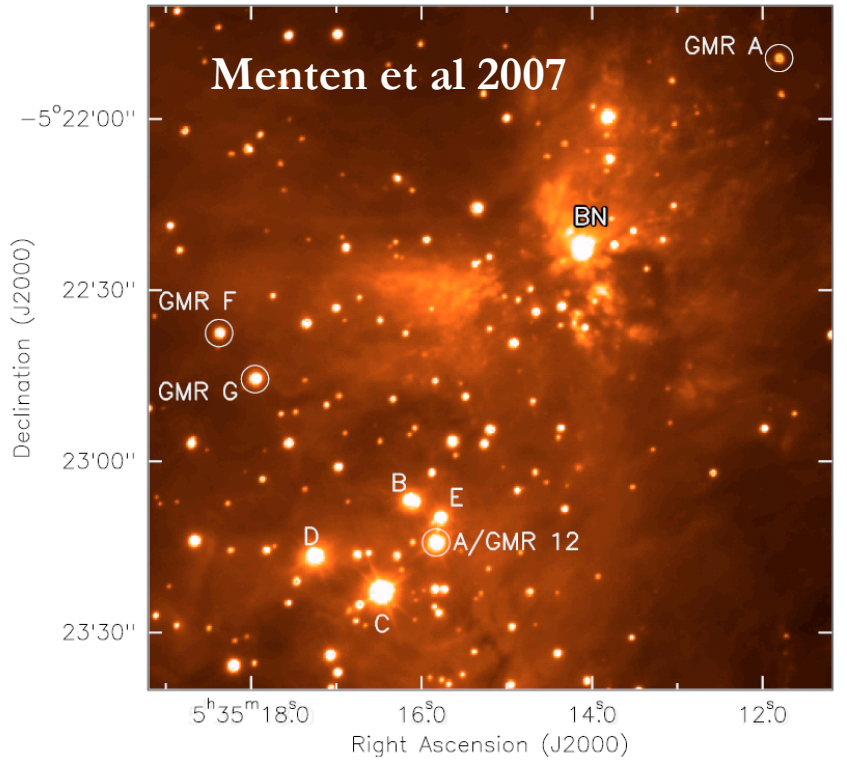
Kazi Rygl, Andreas Brunthaler, Karl Menten, Mark Reid and Huib Jan van Langevelde

Kazi Rygl is member of the IMPRS for Astronomy & Astrophysics

Why are reliable distances important?





Parallax: optical and radio

Optical: Hipparcos & GAIA

- Hipparcos: accuracy: 0.8-2 mas, distances till 200 pc (error 20%)
- GAIA (2011): accuracy ~20 μas, more sensitive to fainter stars

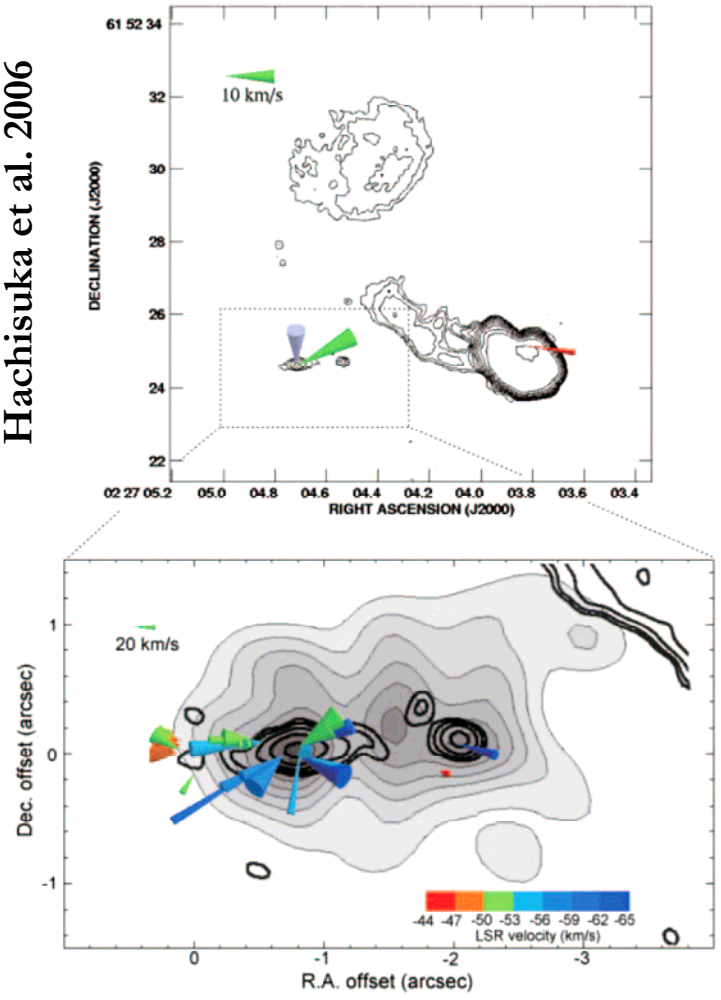
Radio: no extinction of dust!

- VLBI: accuracy of ~100-10 μas for accurate distances to 1 – 10 kpc (errorbar 10%)
- Masers in SFR/AGB stars are strong compact sources for VLBI

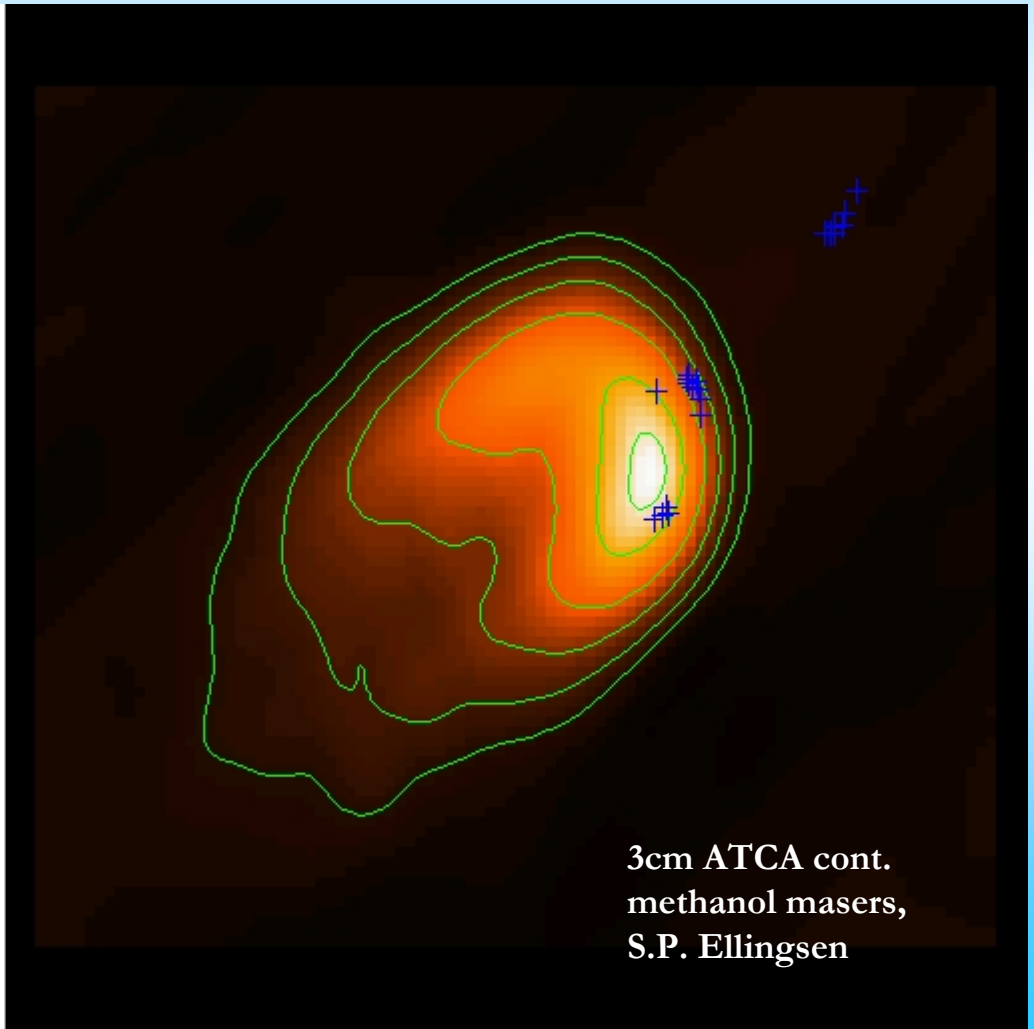
Masers for Parallax

Water masers

Hachisuka et al. 2006



Methanol masers



Methanol masers in MSFR of the Perseus Arm

- 8 well known MSFR: L1206, L1278, ON1, NGC281-W, S255, S252, S269 and MONR2
- 5 epochs of EVN observations
- 1 epoch = 24 hours
- Geodetic-like observations
- Phase referencing on maser

NGC 281: [SII] = Red, H-alpha = Green, [OIII] = Blue

Results 1: S255

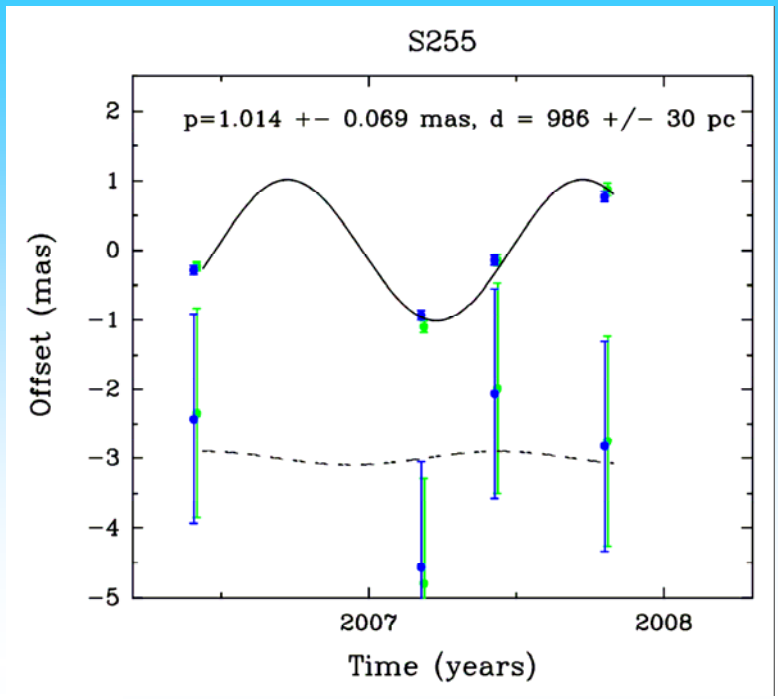
Minier : d=2.5 kpc for MM1 and MM2

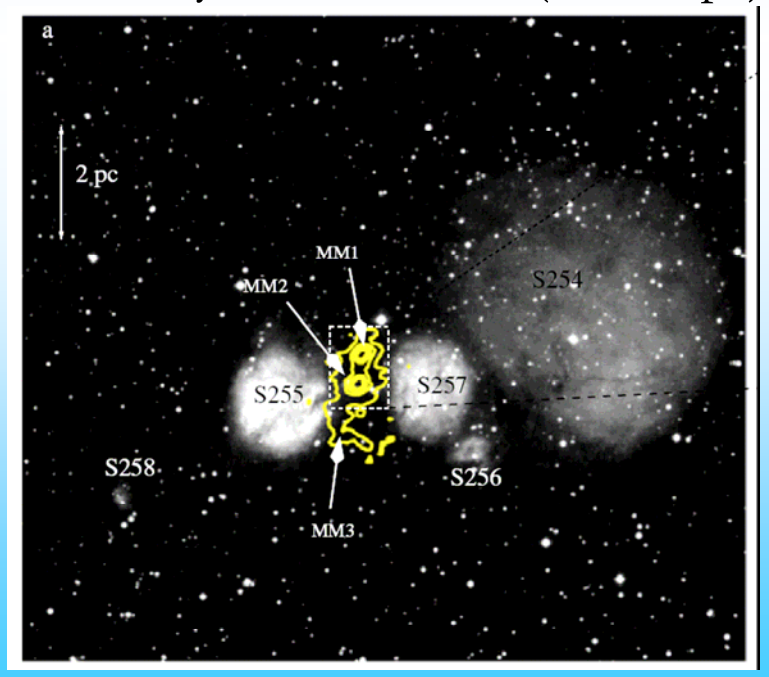
Clump mass 300 Msun, Luminosity 5-10 10^4 Lsun (in 0.3pc)

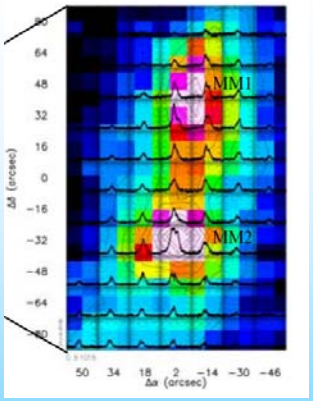
With d = 986 pc,

Mass 48 Msun (estimated from 1.2 mm flux),

Luminosity 8-16 10^3 Lsun (in 0.75 pc)







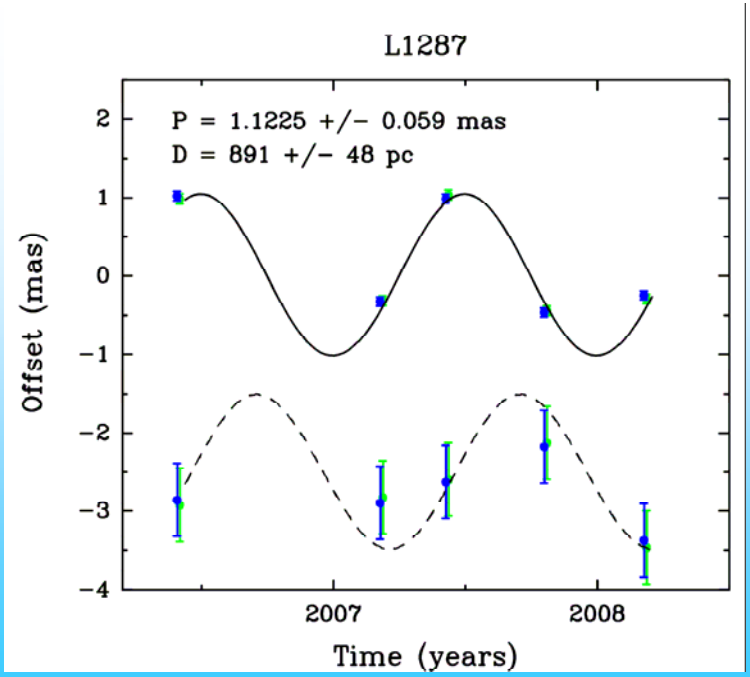
DSS optical image with 1.2 mm dust continuum contours.
HCO+(3-2) line spectra.

(Minier et al 2007)

Results: L1287

MSFR with a collimated outflow,
CO line wings – Yang et al 1991
Kinematic distance (NH_3) 850 pc

Our result: 891 +- 48 pc



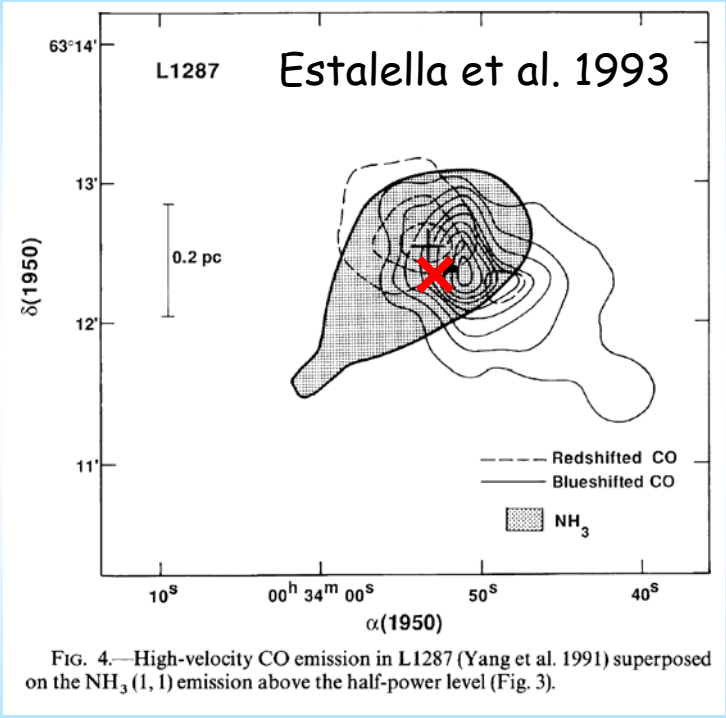


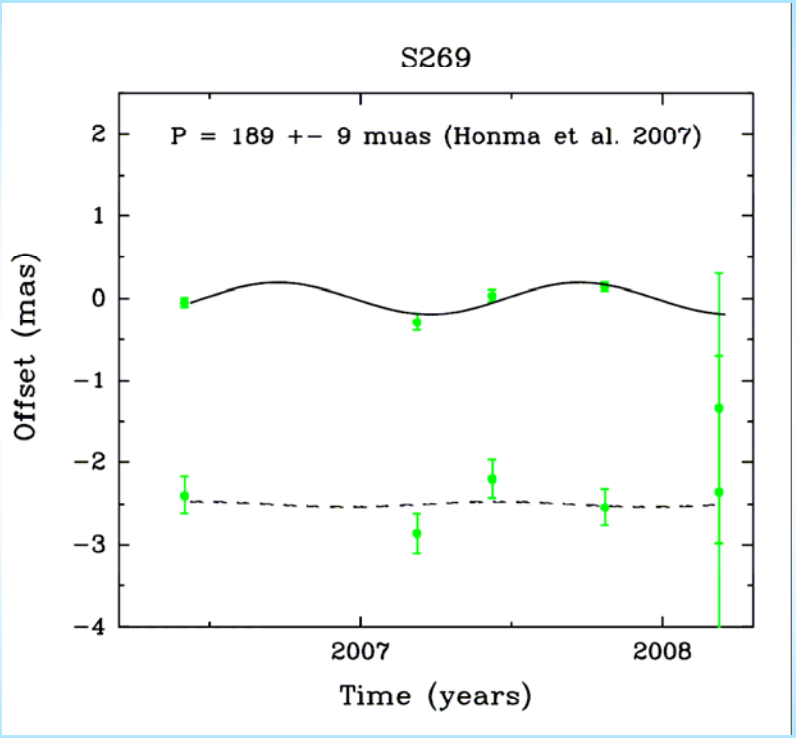
FIG. 4.—High-velocity CO emission in L1287 (Yang et al. 1991) superposed on the NH_3 (1, 1) emission above the half-power level (Fig. 3).

Results & work in progress: S269

- S269 at a distance of 5.3 kpc (Honma et al. 2007, water maser, 6 epochs, 9h), our accuracy is not enough to detect this parallax (5 epochs, ~1.2h)

- Proper motions – methanol masers are more 'stable'

  We can try to verify proper motion of Honma et al.



Summary of distance results

SFR	D_{par} (kpc)	err	D_{kin}(kpc)	Literture D (kpc)
L1287	0.891	5%	0.85	$D_{kin,}$Estalella et al. 1993
ON1	1.75	10%	1.8	D_{kin} MacLeod et al. 1998
S255	0.986	2%	1.1	2.5 Minier et al. 2007
NGC281-W	2.55	31%	2.7	2.8 Sato et al. 2008, parallax
S269	--	--	3.0	5.3 Honma 2007, parallax
S252	--	--	4.4	2.1 Reid 2008, parallax
L1206	t.b.d	t.b.d	1.3	
MONR2	t.b.d	t.b.d	0.94	

Discussion

i. Good results (error ≤ 10%) for sources $\delta > 20$ deg up to a distance of ~2 kpc (at 2.5 kpc we have errorbars of 31%)

ii. Accuracy of ~50 - 100 μas (10-20 x better than Hipparcos)

iii. Covering the peaks of parallax signal improves accuracy

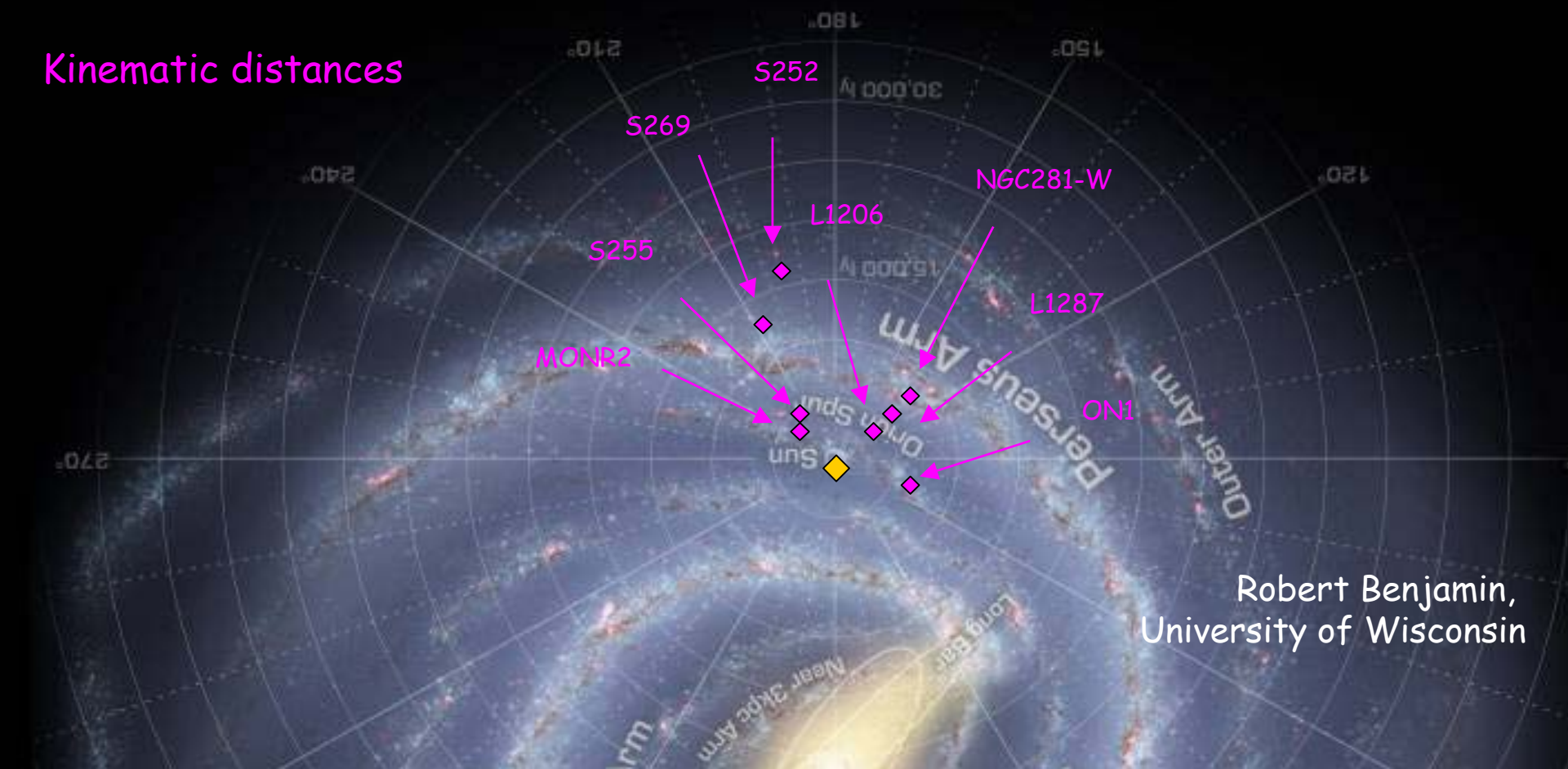
iv. Low declinations ($\delta < 17$ deg) had too few time for a good uv coverage

v. Parallax signature in declination suffers more atmosphere

vi. At 6.7 GHz tropospheric calibrations work in most cases, why not always? ionospheric delay ?

Future prospects

- **3D velocities to study the movement of the MSFR against a Galactic motion**
- **A review of the MSFRs with a 'new' distance**




Thank you for your attention!