Australian Government
Geoscience Australia

Search of primordial gravitational waves with Very Long Baseline Interferometry

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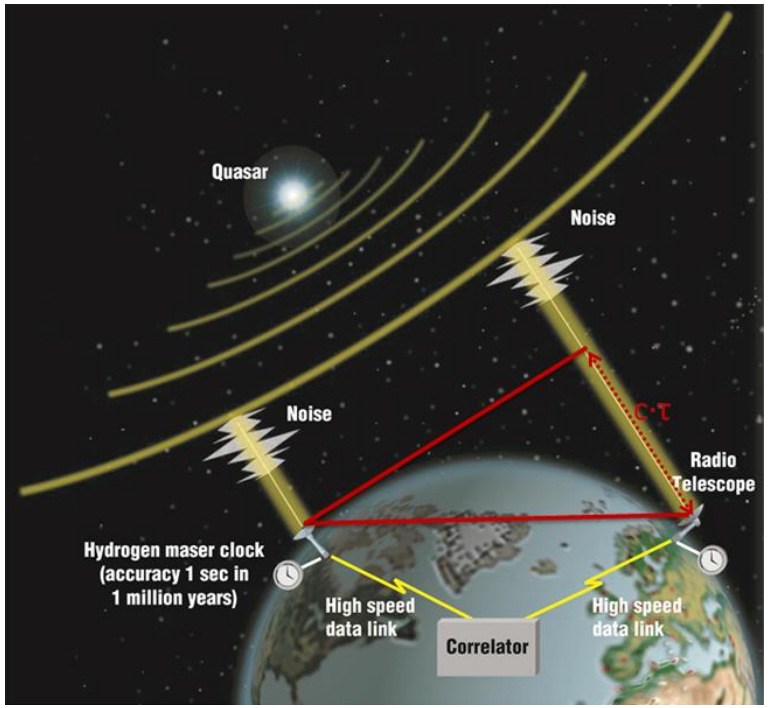
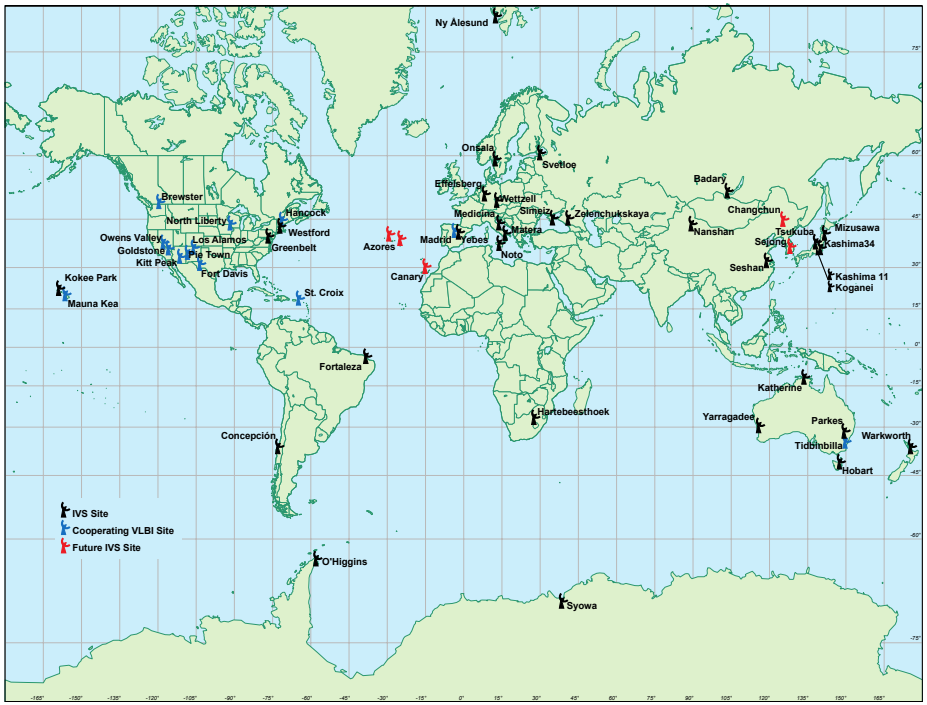
VLBI (concept and map)





http://ivscc.gsfc.nasa.gov/

Accurate astrometry

Individual radio sources have positional accuracy of ~40 μas (ICRF2, 2009) or better (by now).

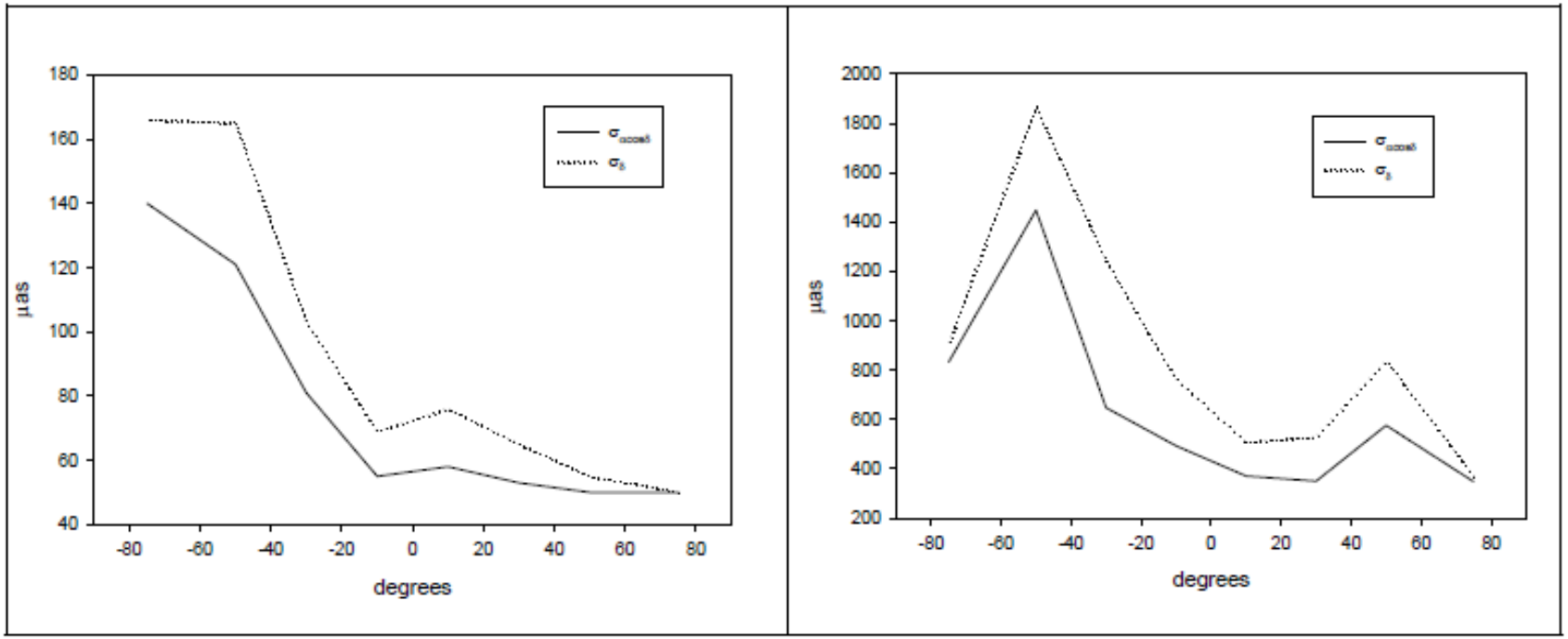


Fig 1. The astrometric accuracy of the 295 ICRF2 "defining" (left) and 922 ICRF "non-defining" (right) reference radio sources as a function of declination.

Proper motions in cosmology

$$\frac{de^{\mu}}{dt} = h^{\mu\nu}[e^{\beta}\sigma_{\nu\beta} +$$

$$+\frac{c}{H_0}\left\{z + z^2\left(\frac{1-q_0}{2}\right)+\ldots\right\}\left\{e^{\beta}\sigma_{\gamma\beta}u_{\gamma\nu} - e^{\beta}E_{\nu\beta} + \frac{1}{2}e^{\beta}e^{\gamma}(u_{\nu\beta\gamma} - \varepsilon_{\nu\beta\lambda}H_{\gamma\lambda}) + e^{\beta}e^{\gamma}e^{\lambda}\sigma_{\nu\gamma}\sigma_{\beta\lambda}\ldots\right\}]+\ldots$$

Kristian, J & Sachs R. 1966, ApJ 143, 37

Another test for the cosmologic model

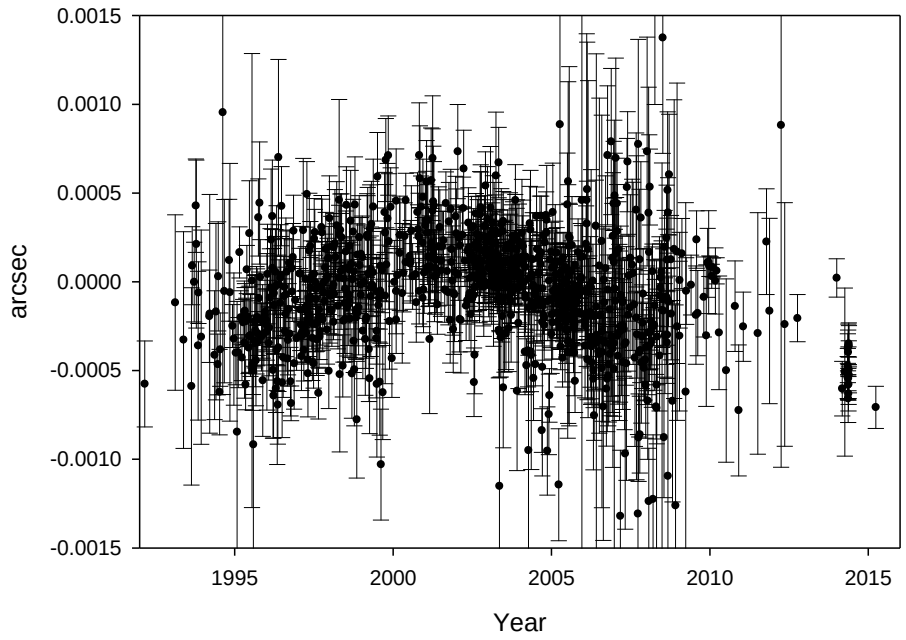
"the major problem is that neither the distortion nor the proper motions are likely to be measurable in practice in the foreseeable future"

(Ellis et al. "Ideal physical cosmology", 1985).

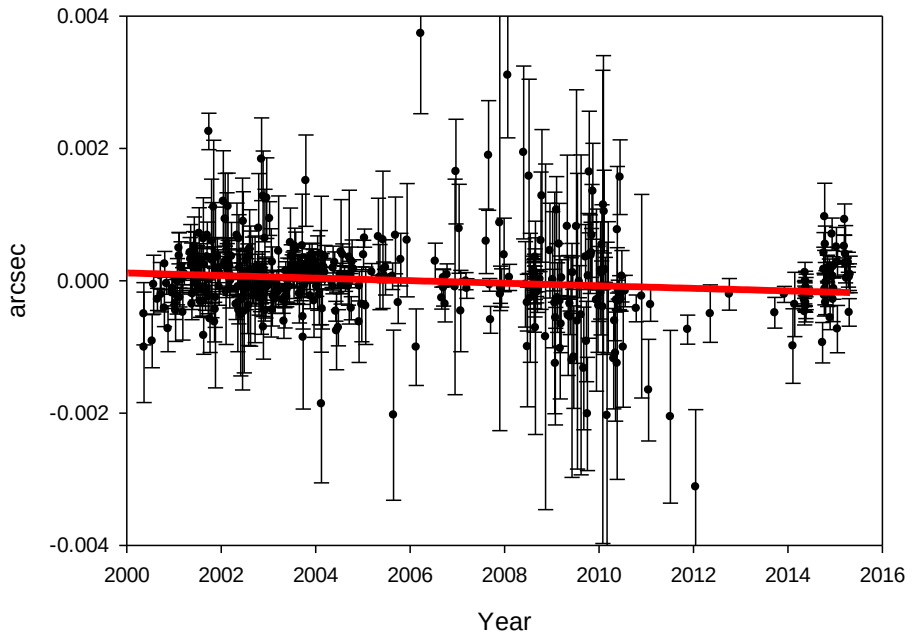
Proper motions

Over 30 years of observations individual proper motions are estimated with accuracy ~ 1 μas/year or better

Declination of 0014+813



Declination of 0106+013



-12 +/- 3 μas/year

Parametrical models (3+3+10)

$$\Delta\mu_\alpha \cos\delta = -d_1 \sin\alpha + d_2 \cos\alpha,$$
$$\Delta\mu_\delta = -d_1 \cos\alpha \sin\delta - d_2 \sin\alpha \sin\delta + d_3 \cos\delta,$$

Secular aberration drift due to Solar system galactocentric acceleration

$$a = 2 \cdot 10^{-13} km/\sec^2 \rightarrow 4\mu as/year$$

$$\begin{aligned}\Delta\mu_\alpha \cos\delta = {} & a^{M}_{2,0} \sin 2\delta \\ & + \sin\delta\left(a^{E,\mathrm{Re}}_{2,1} \sin\alpha + a^{E,\mathrm{Im}}_{2,1} \cos\alpha\right) \\ & - \cos 2\delta\left(a^{M,\mathrm{Re}}_{2,1} \cos\alpha - a^{M,\mathrm{Im}}_{2,1} \sin\alpha\right) \\ & - 2\cos\delta\left(a^{E,\mathrm{Re}}_{2,2} \sin 2\alpha + a^{E,\mathrm{Im}}_{2,2} \cos 2\alpha\right) \\ & - \sin 2\delta\left(a^{M,\mathrm{Re}}_{2,2} \cos 2\alpha - a^{M,\mathrm{Im}}_{2,2} \sin 2\alpha\right),\end{aligned}$$

$$\begin{aligned}\Delta\mu_\delta = {} & a^{E}_{2,0} \sin 2\delta \\ & - \cos 2\delta\left(a^{E,\mathrm{Re}}_{2,1} \cos\alpha - a^{E,\mathrm{Im}}_{2,1} \sin\alpha\right) \\ & - \sin\delta\left(a^{M,\mathrm{Re}}_{2,1} \sin\alpha + a^{M,\mathrm{Im}}_{2,1} \cos\alpha\right) \\ & - \sin 2\delta\left(a^{E,\mathrm{Re}}_{2,2} \cos 2\alpha - a^{E,\mathrm{Im}}_{2,2} \sin 2\alpha\right) \\ & + 2\cos\delta\left(a^{M,\mathrm{Re}}_{2,2} \sin 2\alpha + a^{M,\mathrm{Im}}_{2,2} \cos 2\alpha\right).\end{aligned}$$

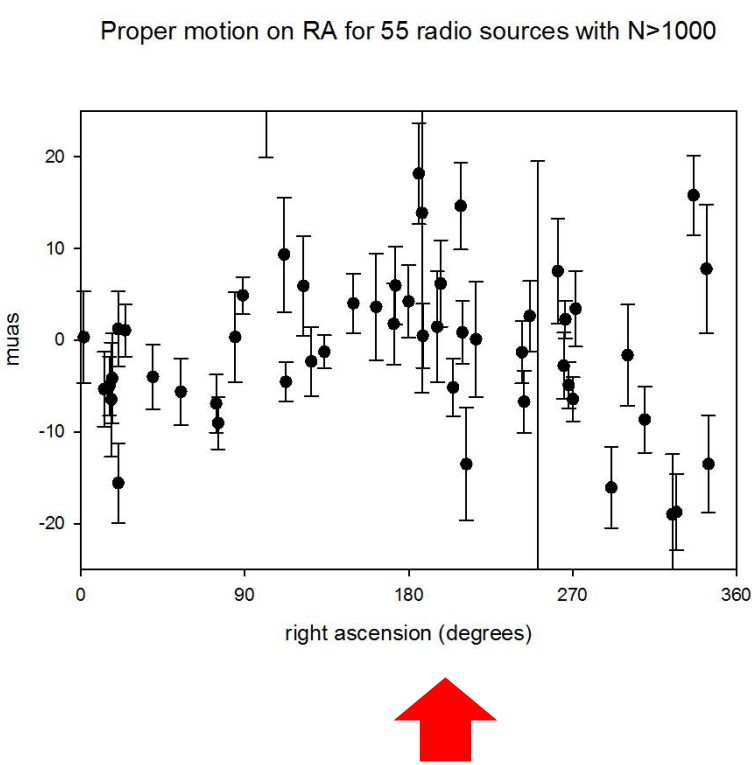
Electric type GW or Hubble constant anisotropy

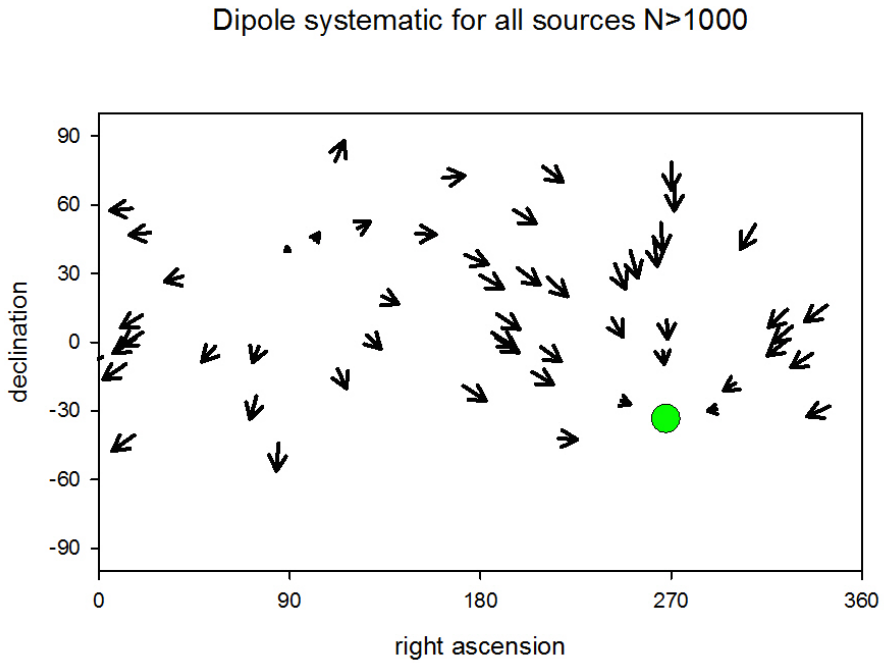
Magnetic type GW

Gwinn, K et all, ApJ, 1998
Titov, O et al, 2011, A&A 529, 91

Secular aberration drift (dipole effect)

The most observed 55 radio sources (>1000 sessions)





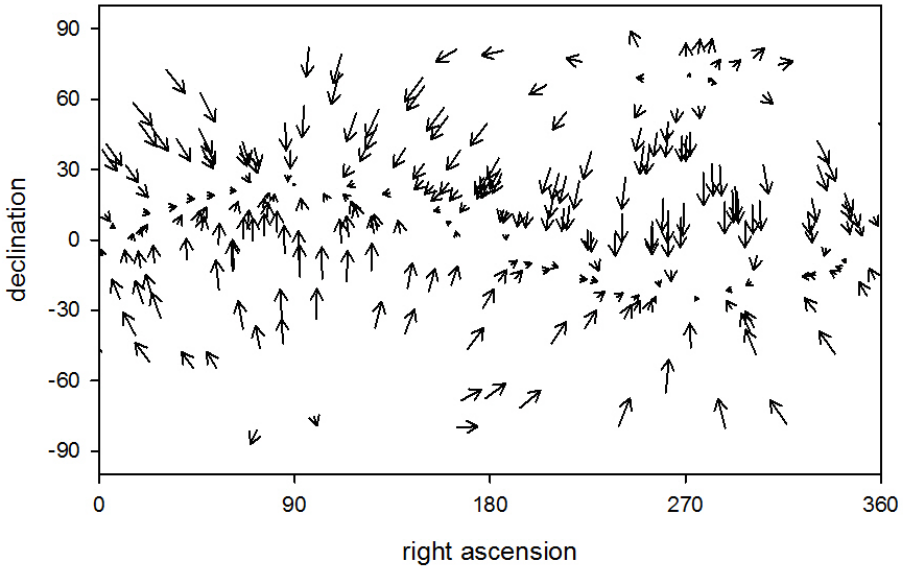
Systematic is observable!

$$a = 6 \mu as / year$$

Quadrupole systematic (electric type for z<0.9)

Second order systematic (electric type) for low-redshift radio sources

256 ‘close’ sources (z<0.9)



	Dipole only	16 parameters
Amp (μas/year)	3.7 +/- 1.3	4.1 +/- 1.5
RA (deg)	285 +/- 23	283 +/- 22
De (deg)	-44 +/- 20	-17 +/- 23
Rot (μas/year)		3.6 +/- 1.2
Second harm (μas/year)		7.8 +/- 1.5

Electric	Magnetic
5.1 +/- 2.0	0.9 +/- 1.7
-0.0 +/- 1.8	-2.7 +/- 1.6
-0.1 +/- 0.8	-1.6 +/- 1.0
-0.2 +/- 0.8	-0.2 +/- 1.0
-4.8 +/- 1.9	1.3 +/- 1.5

Ω(GW) may be constrained from the data

Any Questions?

Thank you for your attention!

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