Could jets showing bends or wiggles be relativistically beamed?

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Programme

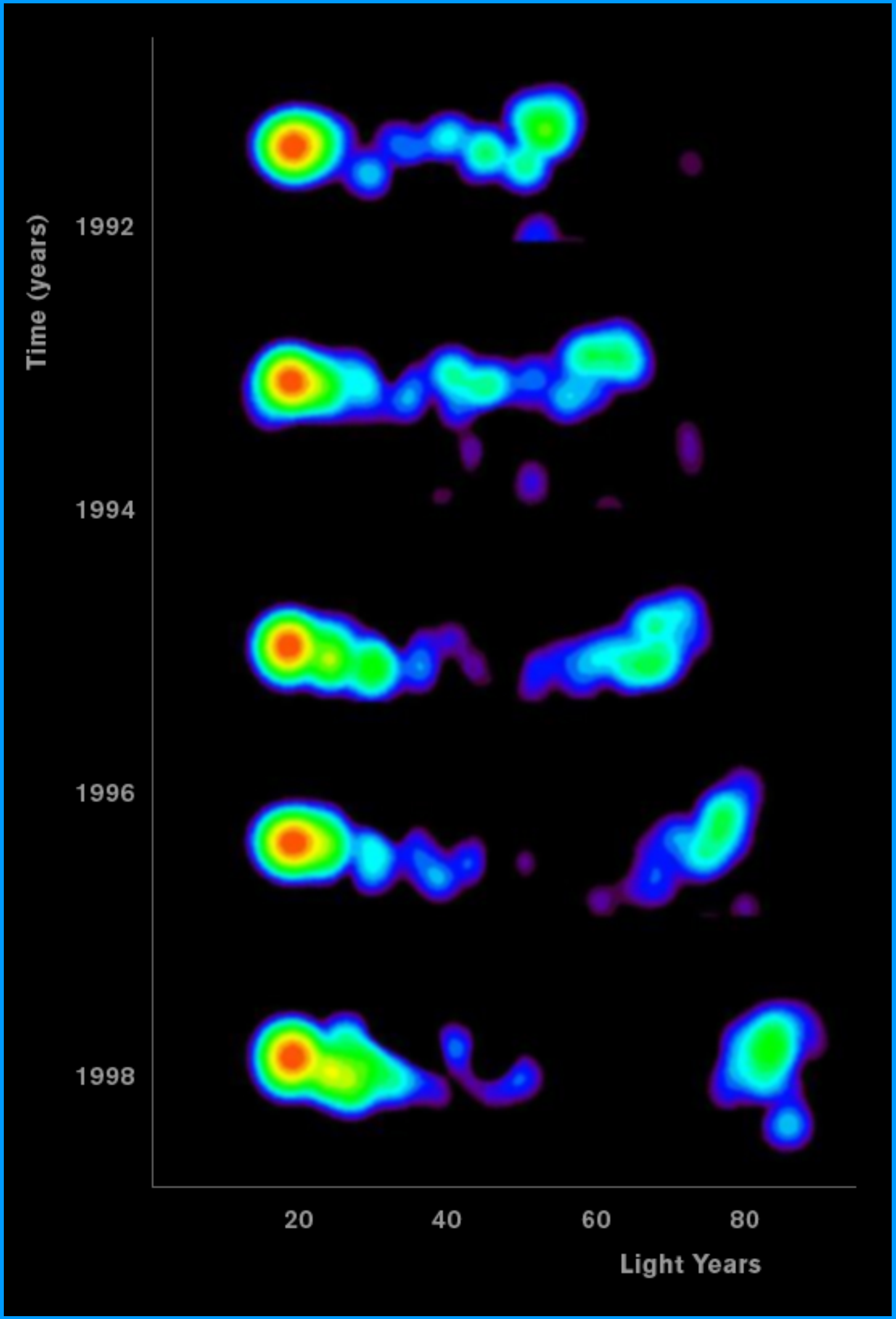
Saturday, 17th October, 2015

Reception of Barat .... 10:30 am

Anand Karaj.................................... 12:00 pm

Doli .... 04:00 pm

3C279 Superluminal motion-



Relativistic Beaming

$$\delta = 1/(\gamma(1 - \beta\cos\theta))$$

$$\delta^{n+\alpha}$$

$$I_\nu \propto \nu^{-\alpha}$$

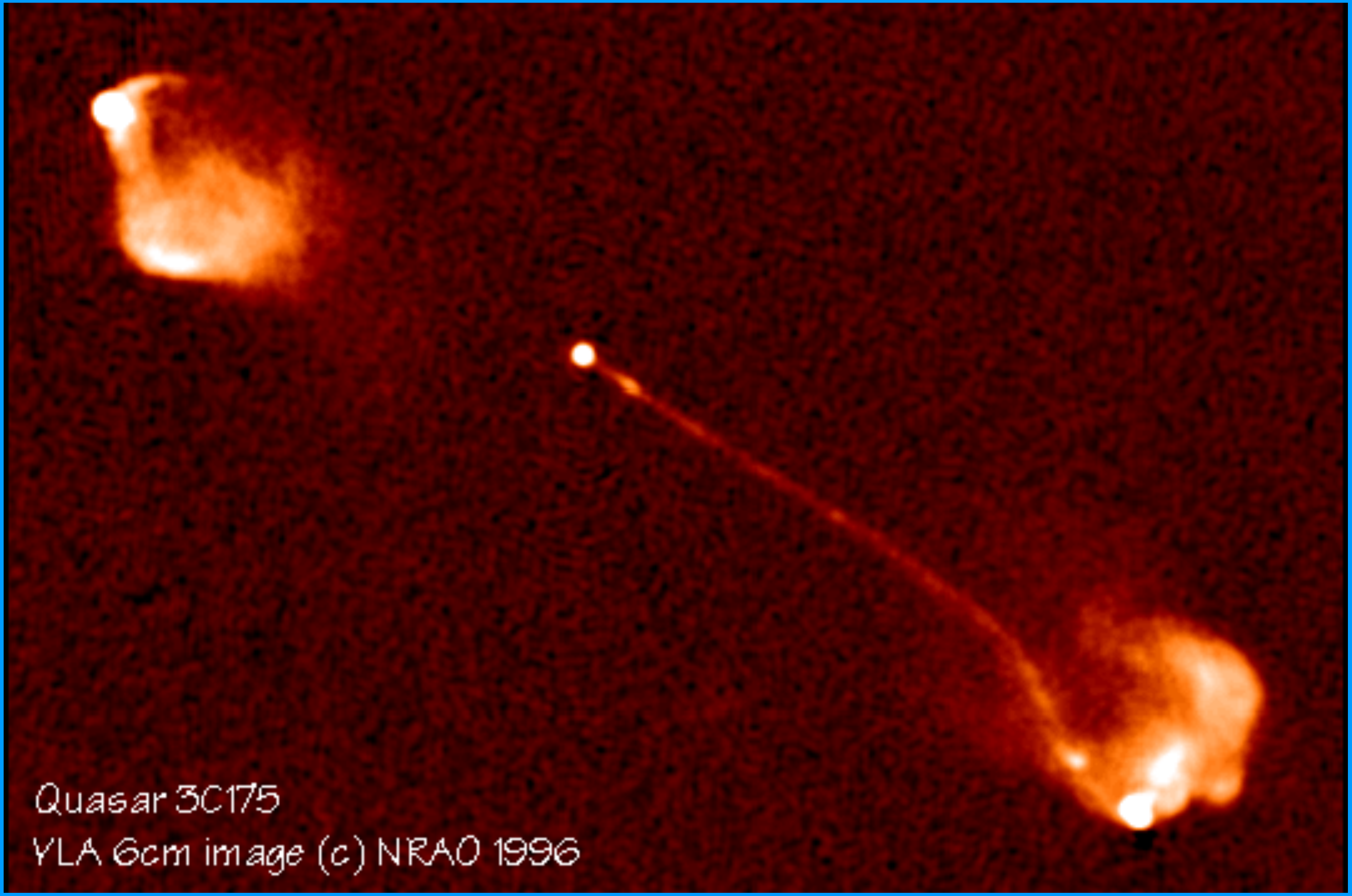
$$\gamma = 1/\surd(1 - \beta^2)$$

$$\sin\theta = 1/\gamma$$

$$\sin\theta = \surd(2\,/1 + \gamma)$$

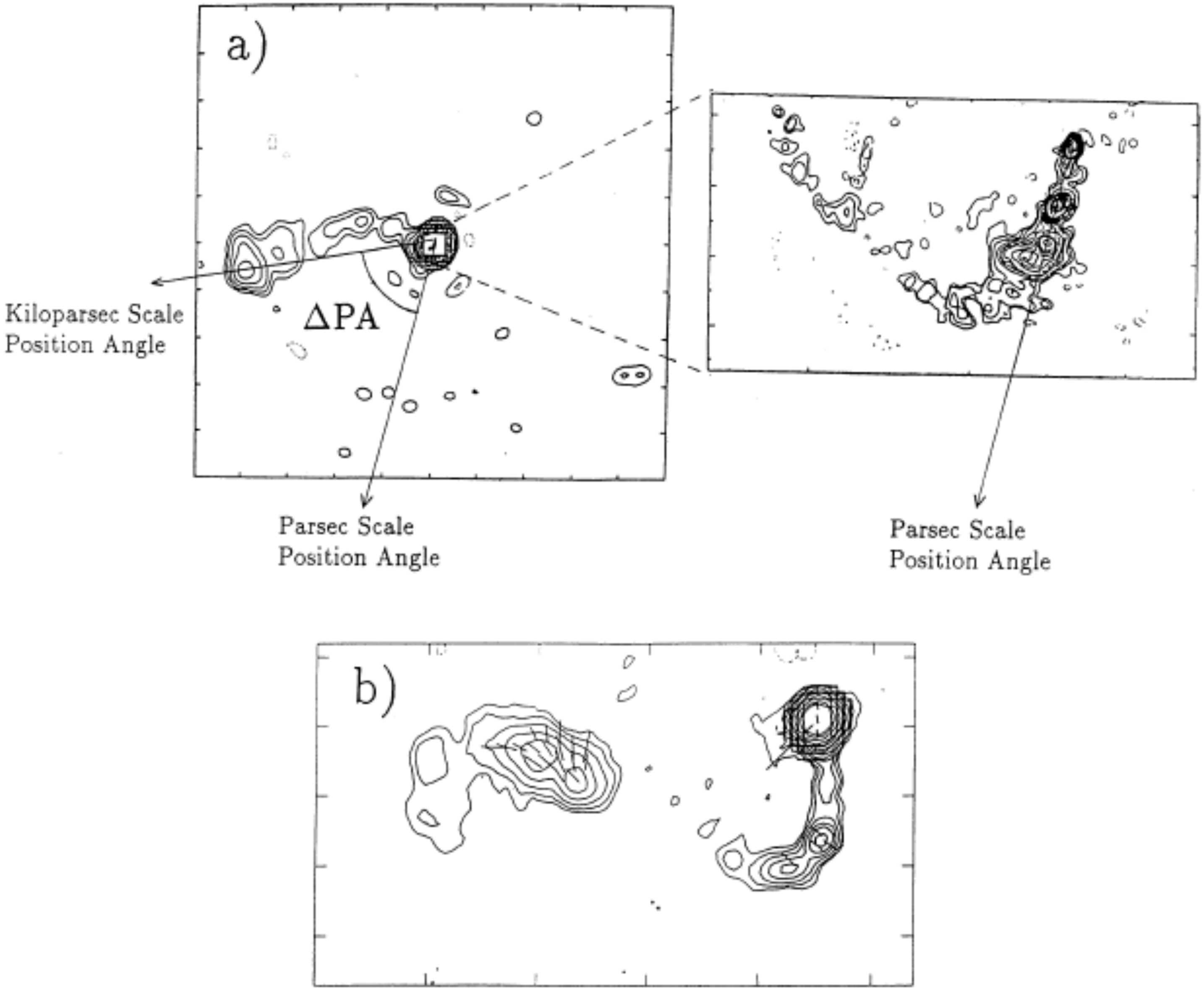
$$\delta = 1/\gamma \text{ for } \theta = \pi/2$$

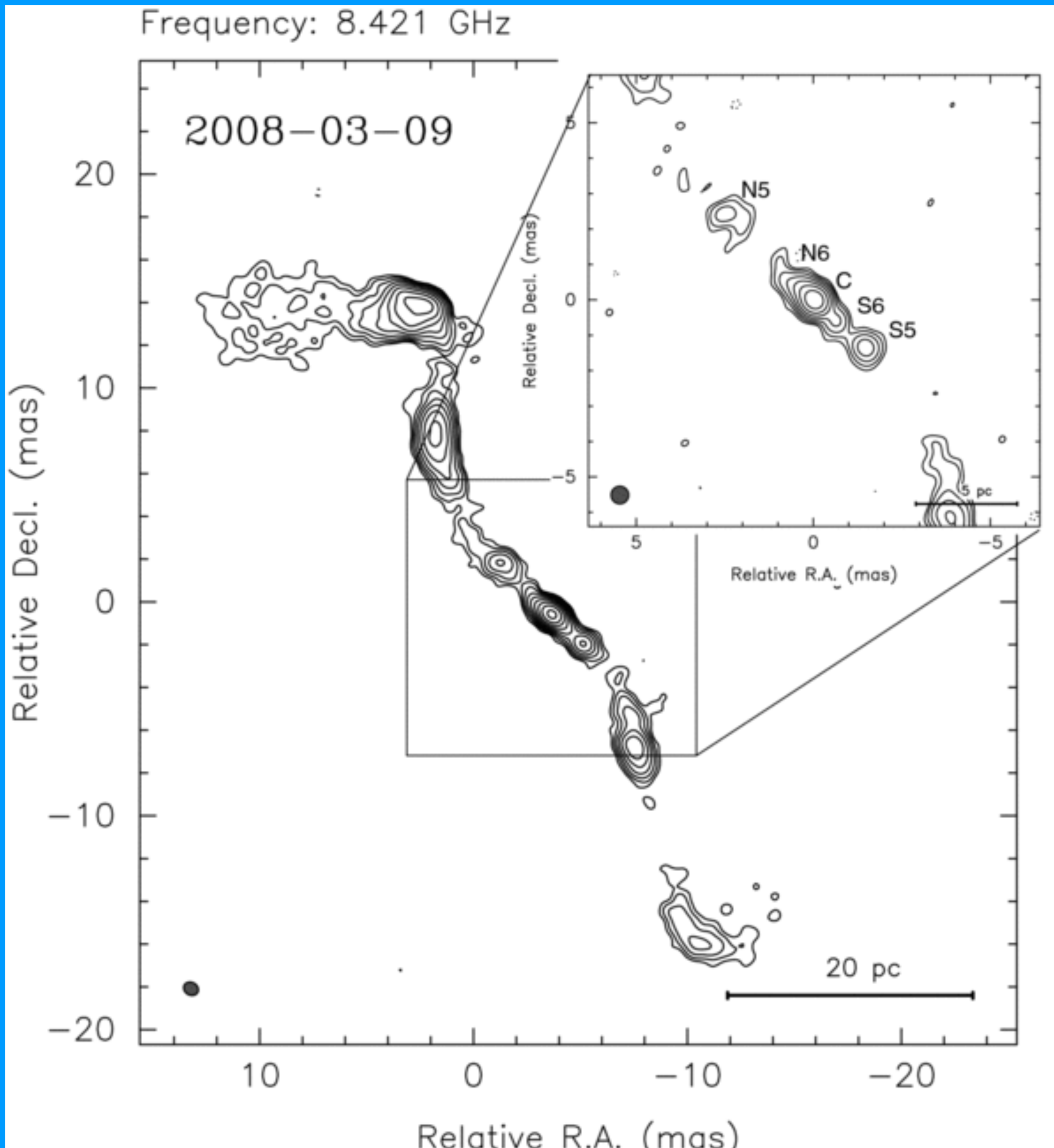
Beaming effect – one-sided jet



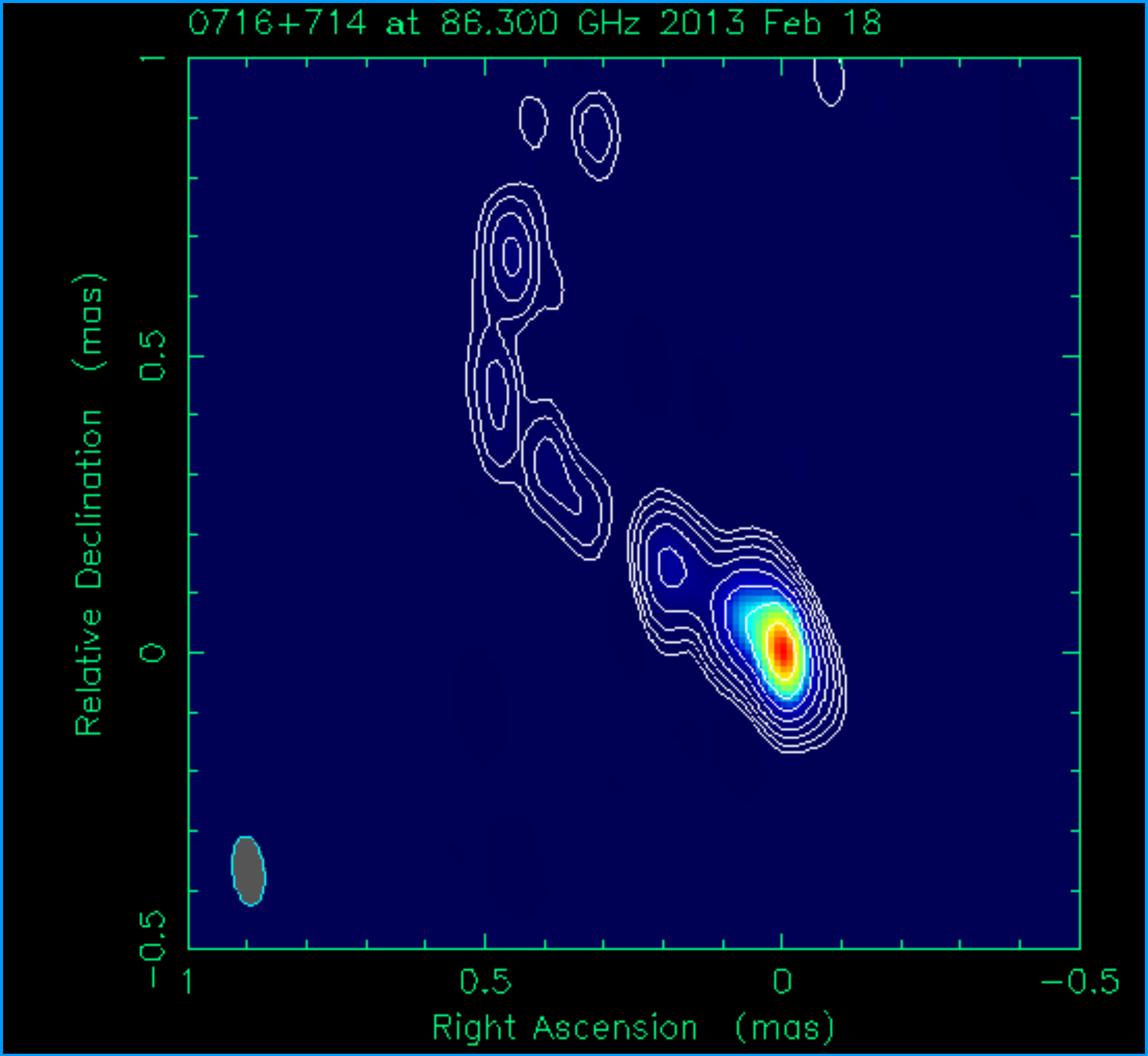
Typically δ could be (from superluminal motion) $\sim 5-40$, though there are indications that δ could be much higher from high brightness temperatures that exceed the incoherent synchrotron limit of $\sim 10^{12}$, initially thought to be due to large increase compton losses at $T > 10^{12}$, also called in literature for long as Inverse Compton limit, but later shown to be due to the diamagnetic effects in the source which lead to condition of equipartition among radiating charges and the manetic field (which is also the configuration of minimum energy for the source) which forbids $T_b > 10^{11.3}$ or so. However there are occasional reportss of T_b seen up to $\sim 10^{21}$ or so, implying δ as large as $\delta > 10^3$, though typical values might be $\delta \sim 10-100$. Thus the presence of a relativistic flow and of relativistic beaming is quite evident.

Bending of Jets

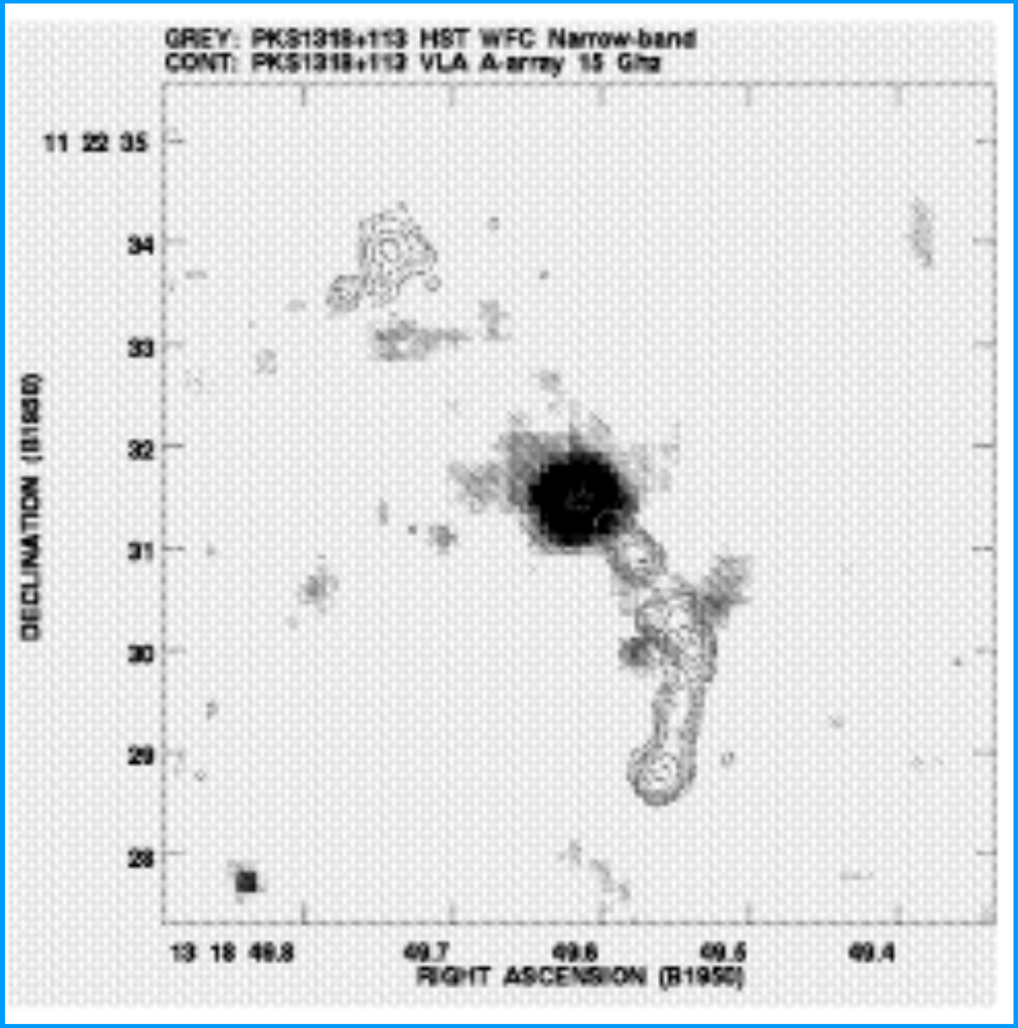




Frequency: 8.421 GHz
2008−03−09
Relative Decl. (mas)
Relative R.A. (mas)
20 pc
N5
N6
C
S6
S5
5 pc


0716+714 at 86.300 GHz 2013 Feb 18
Relative Declination (mas)
Right Ascension (mas)
1
0.5
0
−0.5
1
0.5
0
−0.5

PKS 1318 + 113


GREY: PKS1318+113 HST WFC Narrow-band
CONT: PKS1318+113 VLA A-array 15 Ghz
11 22 35
34
33
32
31
30
29
28
DECLINATION (B1950)
13 18 49.8
49.7
49.6
49.5
49.4
RIGHT ASCENSION (B1950)

A question may arise whether one should use δ^3 or δ^2 for Doppler beaming for the jets? Actually if one is considering the integrated jet emission, then one should use δ^2 as a beaming factor. This is because the time compression due to δ factor in the oncoming jet component, that may last a time τ in the intrinsic frame, means the component will be visible for a shorter duration τ/δ. So on the whole in the integrated jet emission one will see only the parts of jet that were "born" only a time τ/δ back. Thus there will be less number of components visible at any time by the factor δ, so less integrated emission by that factor.

flux boosting $\Gamma = \delta^{3+\alpha}$ (with $\alpha \sim 0.5 - 1$), for $\delta \sim 10 - 100$ would imply flux boosting $\Gamma \sim 10^3$ to 10^6 or even larger, means the observed flux is a very sensitive factor of the orientation angle θ of the jet with respect to the line of sight to the obserever. Now if there is a slight change in angle θ, it would cause a very large change in the observed flux density.

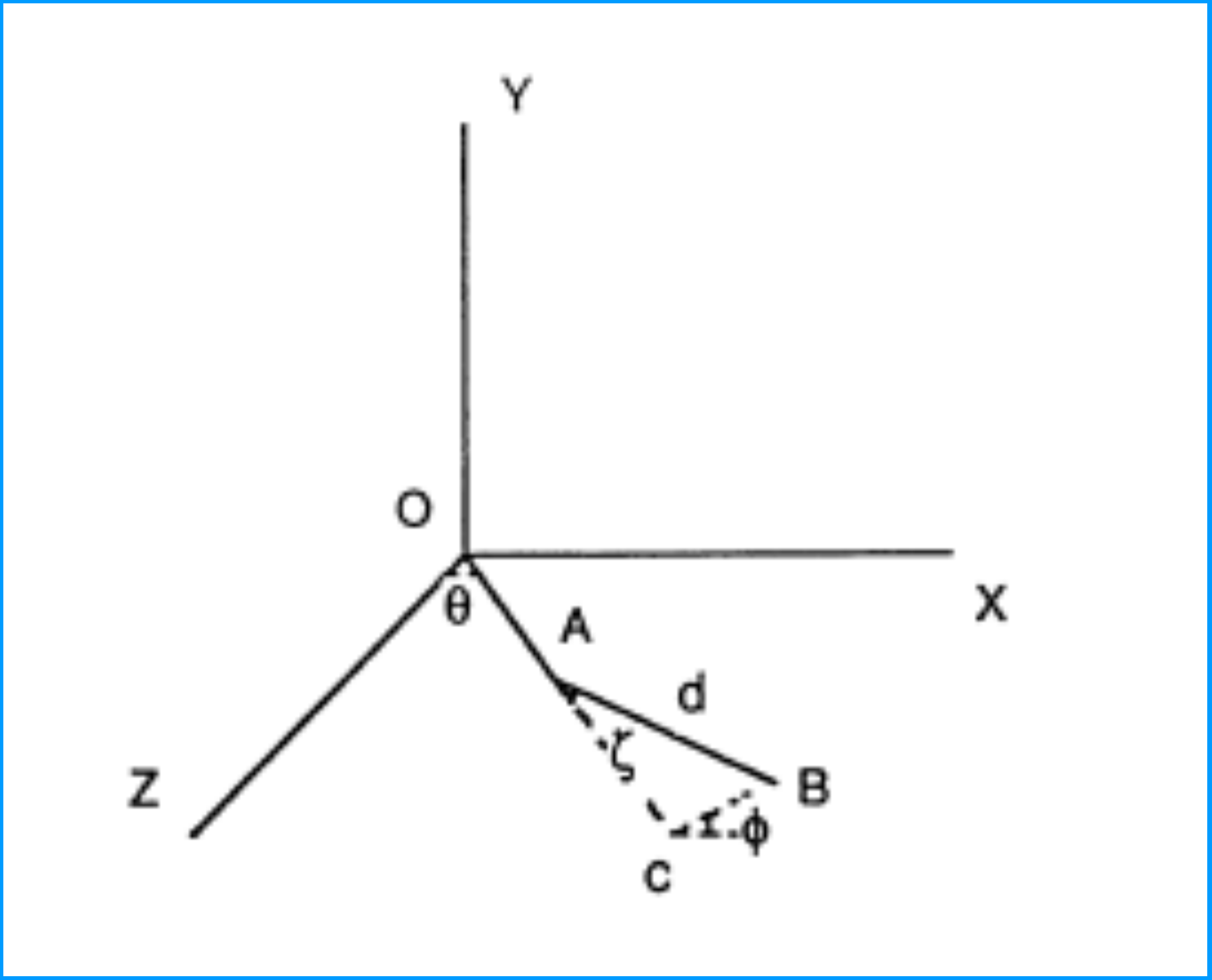
Bends and wiggles

And if a jet is observed as heavily beamed then, being close to line of sight ($\sin\theta \approx 1/\gamma$), then we do not expect it to show many bends or wiggles, because any change in angle will change the beaming by a large factor, causing a large drop in jet brightness, so bends or wiggles should appear more like gaps, and of course the question may arise what might cause such sharp wiggles in highly relativistic material, especially if it come back to original orientation repeatedly as in a wiggle.

A change in the magnitude of the relativistic jet velocity β, and thereby also a change in the Lorentz factro γ, alone would not cause a change in the apparent direction of the jet seen by the observer, though the brightness could change substantially depending upon the change in the jet speed. A change in the direction of jet motion is a must to show up as a bending in the jet direction, projected in the sky plane, as seen by the observer.

Here we assume that it is only the direction, and not the magnitude of the relativistic jet velocity β, that undergo any change. This is to ascertain a minimum number of changes that need to be considered to explain the observations. We consider therefore changes only in the deprojected angle θ in the motion of the jet material from the line of sight to the observer. It would be a very contrived scenario to think of a change in θ and a suitable change in the jet speed (and therefore a change in γ) that could manage to give a simialr brightness of the relativistically moving jet.

Geometry of jet observation



Jet inclination angle

ζ is the intrinsic change in the jet angle with respect to its initial direction

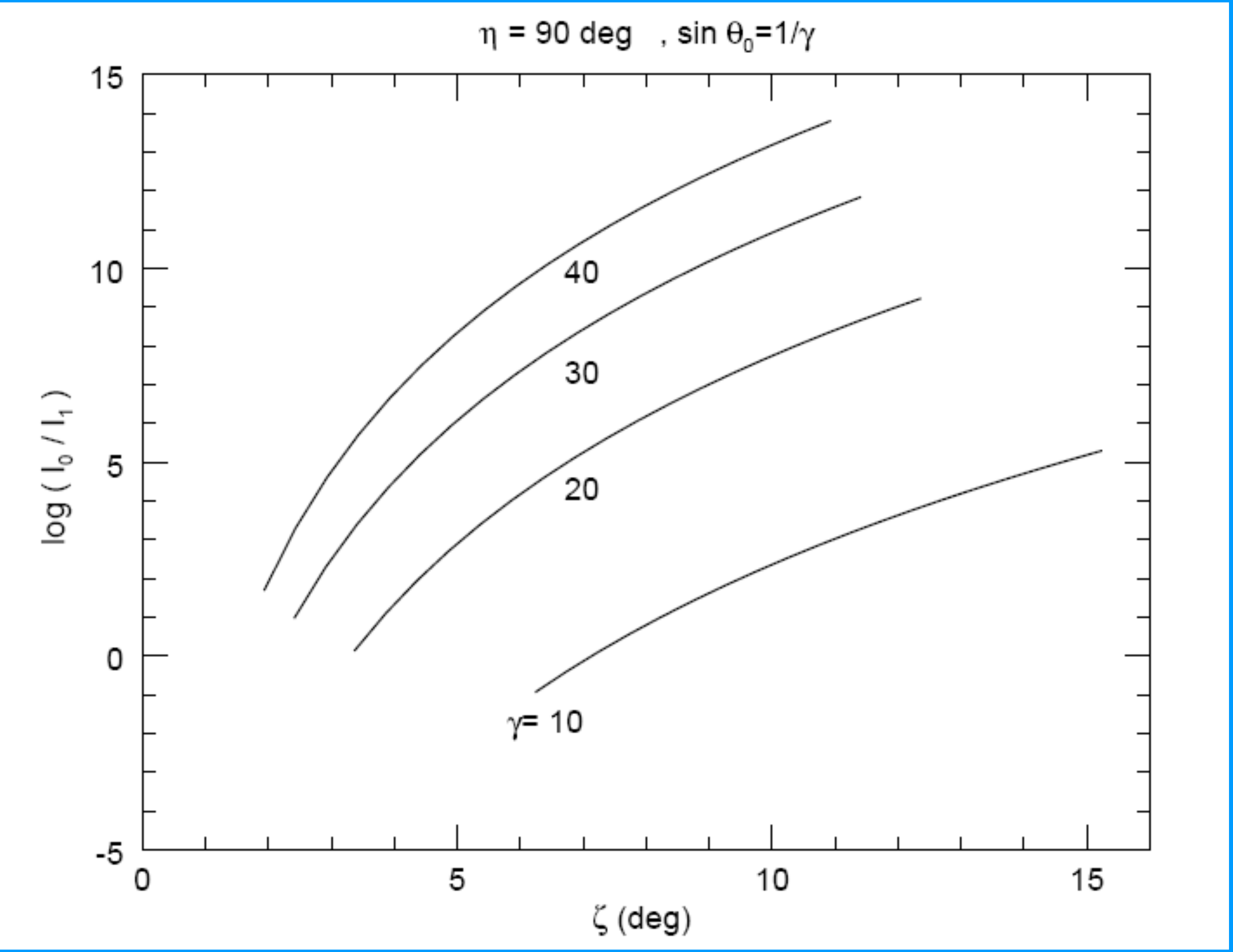
(we take the change to be a sudden discontinuous change and not a gradual turning)

ζ lies in a plane that makes an angle ϕ with respect to the plane containing the initial direction of the jet and the line of sight to the observer.

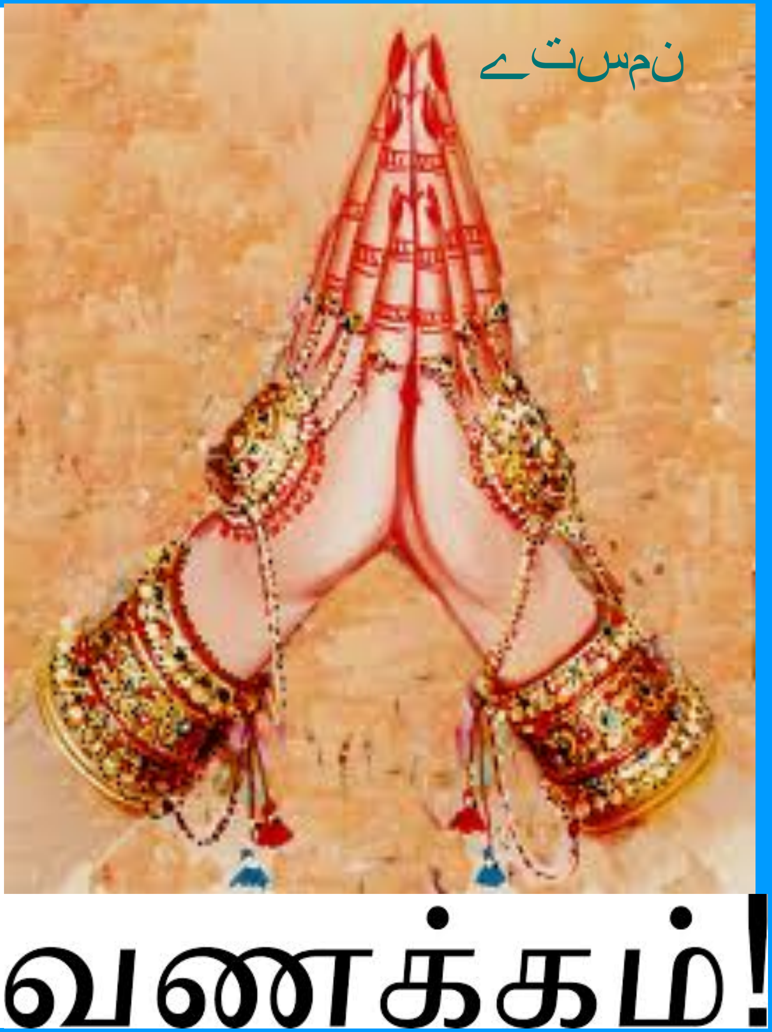
Then the jet bending seen as projected in the sky plane is given by,

$$\tan\eta = \frac{\sin\zeta\sin\phi}{\cos\zeta\sin\theta + \sin\zeta\cos\phi\cos\theta}$$

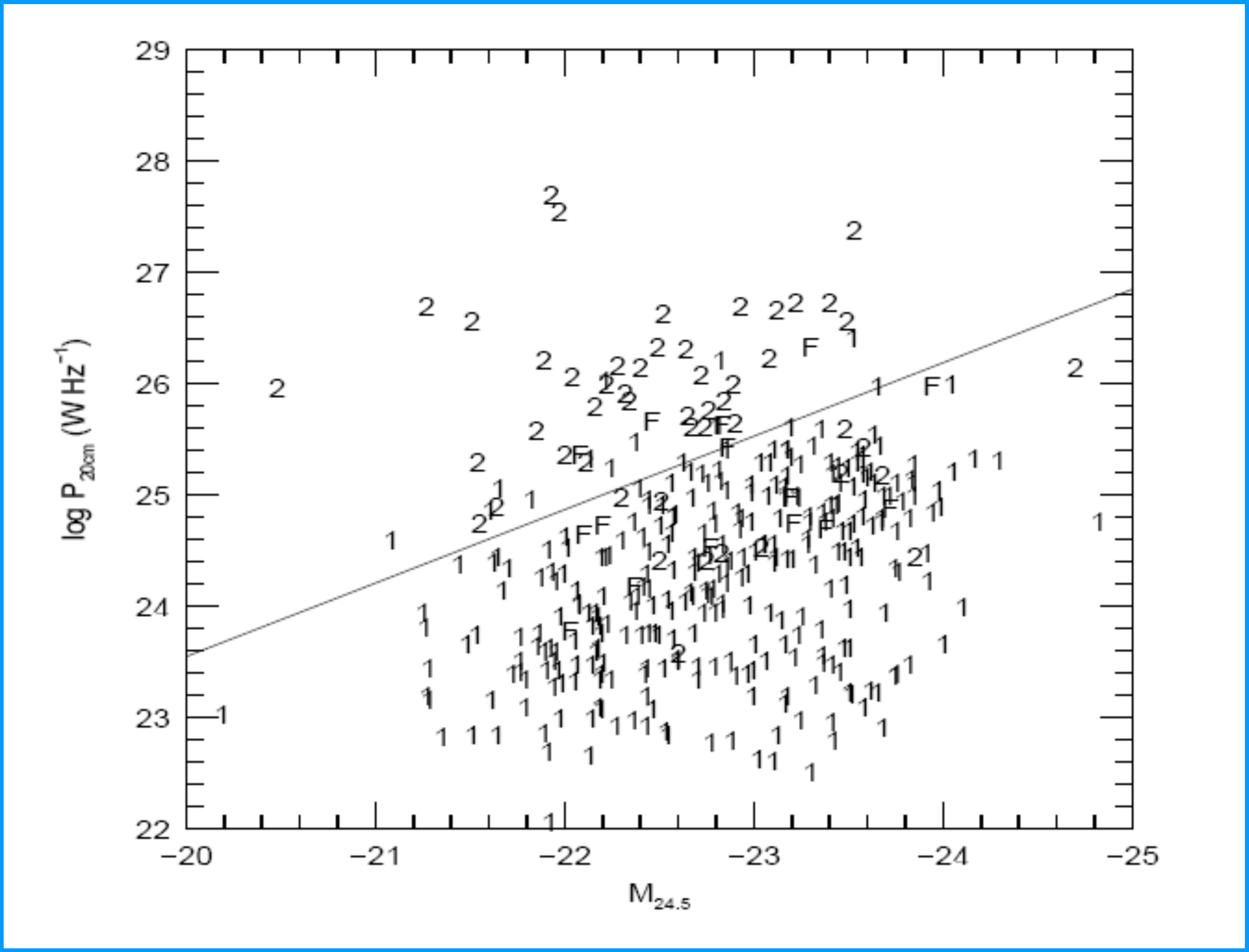
$$\cos\theta_1 = \cos\zeta\cos\theta - \sin\zeta\cos\phi\sin\theta$$


η = 90 deg , sin θ0=1/γ
log (I0 / I1)
ζ (deg)
15
10
5
0
-5
0
5
10
15
40
30
20
γ= 10

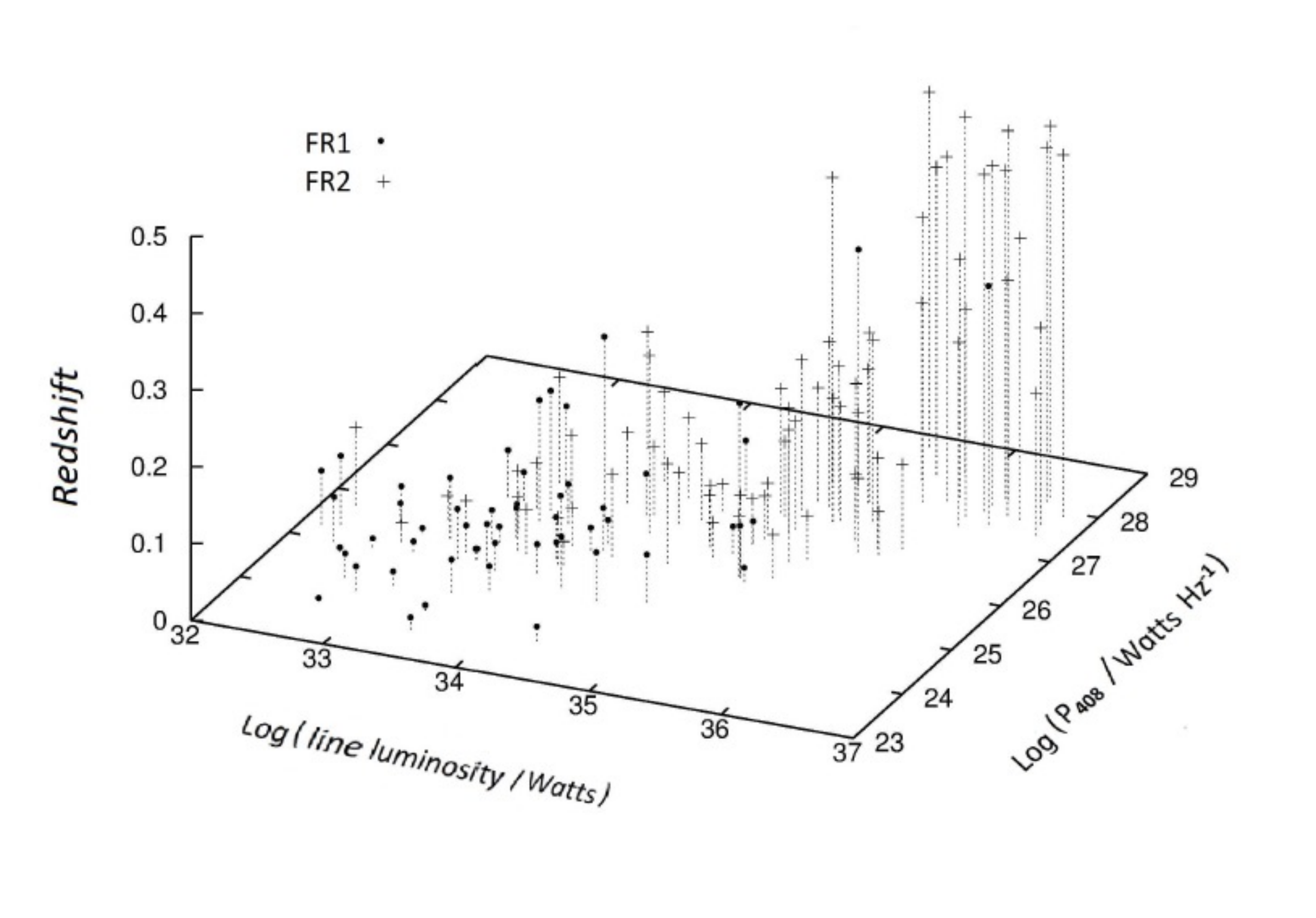
Namaste!

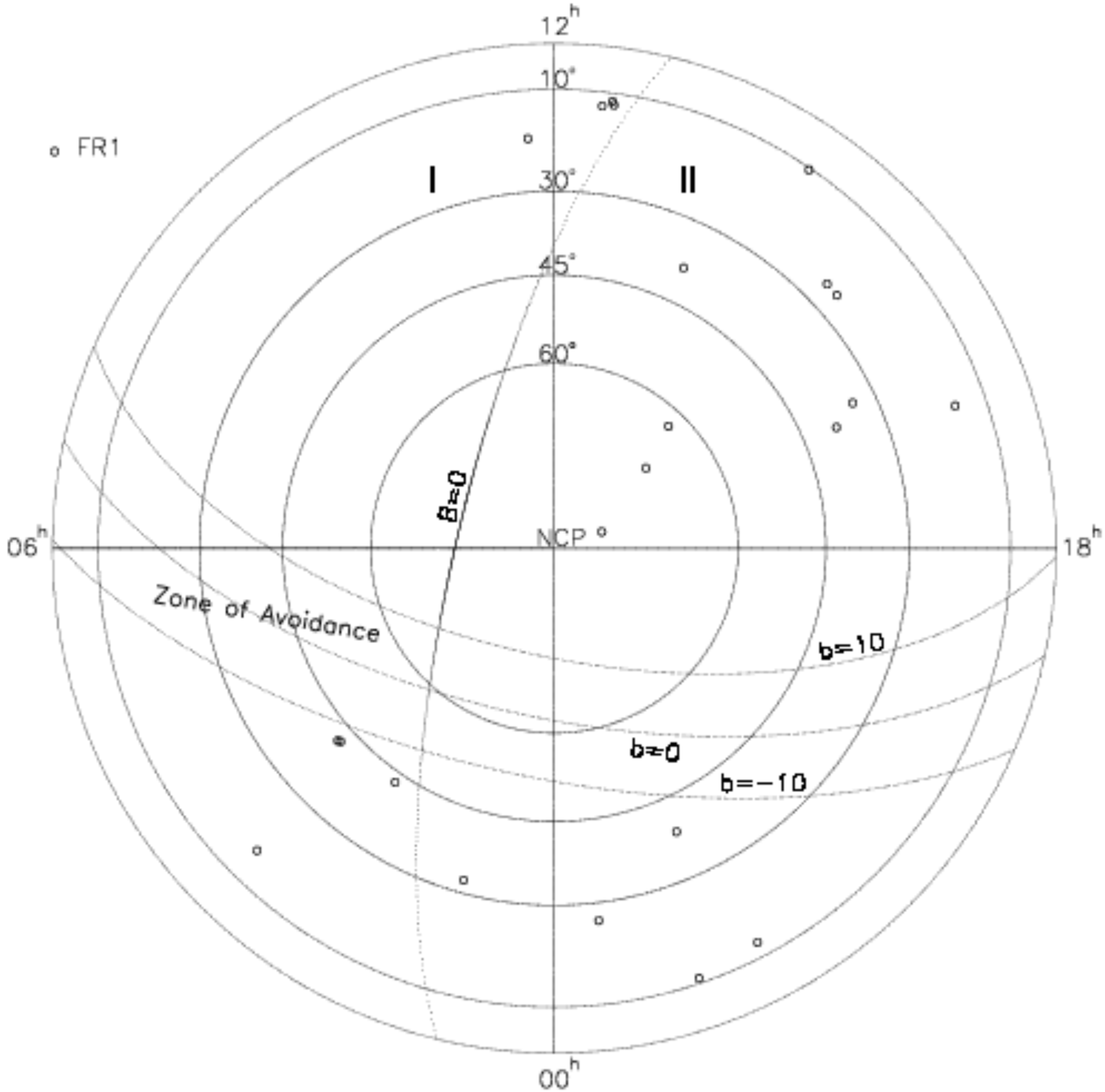


Owen & Ledlow plot



A 3-d plot makes things clearer Zirbel & Baum 95 data




12h
10°
30°
45°
60°
FR1
I
II
B=0
NCP
06h
18h
Zone of Avoidance
b=10
b=0
b=-10
00h

Do LEGs form an intermediate class between FR1s and HEGs?

FR1s: lower redshifts and luminosities, edge-darkened morphology, Low-excitation spectra

LEGs: intermediate redshifts and luminosities, edge-brightened morphology, Low-excitation spectra

HEGs: High redshifts and luminosities, edge-brightened morphology, High-excitation spectra