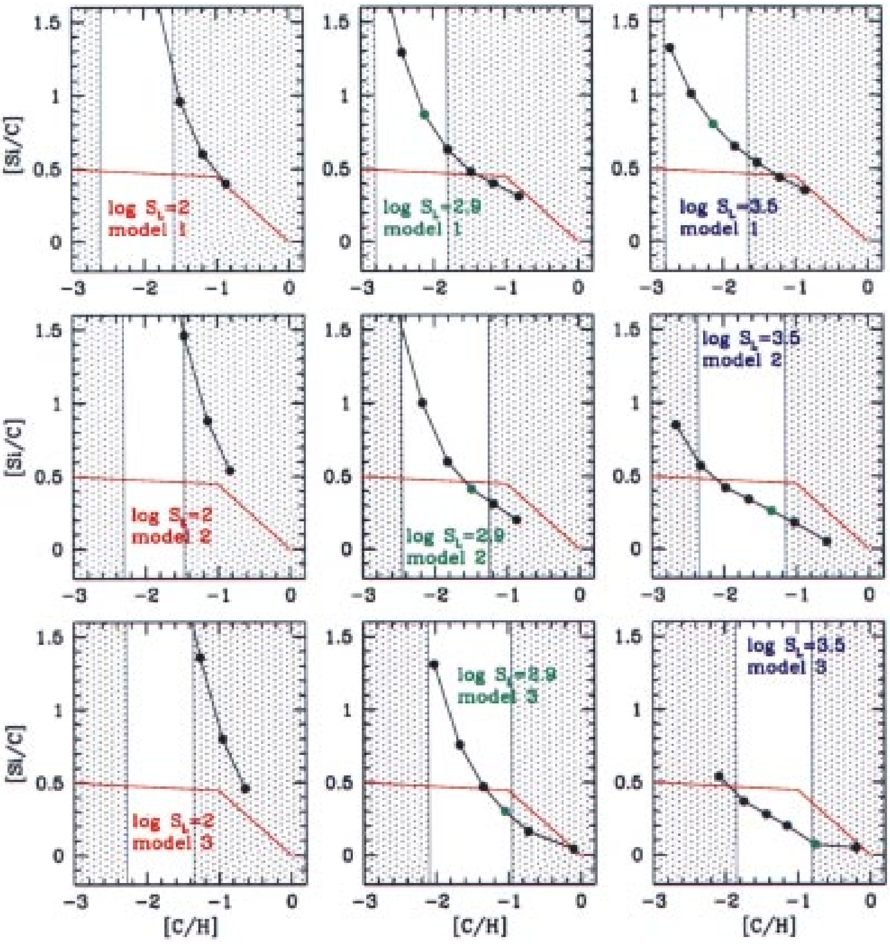

Figure 3: Silicon-to-carbon ratio as a function of the carbon-to-hydrogen ratio for the absorbing system at z = 3.8190 observed in Q0000-26 ([X/Y] = log(X/Y)$_\odot$ – log(X/Y)). Both values are compared to the solar values. The dots are results of CLOUDY calculations obtained varying the gas density n_H with a 0.2 dex step. The green dot indicates the result for log n_H = –3.1. Lower densities have higher [C/H] values, while higher densities have lower [C/H] values. The shaded areas indicate the regions where the cloud sizes become smaller than 1 kpc (right side) or larger than 50 kpc (left side). The results are shown for three different models of J_ν and three different S_L values.

The expected values of [Si/C] can be reproduced by the models with log S_L = 2 only assuming a cloud size by far smaller than 1 kpc and this would give a metallicity for this cloud larger than 1/10 of solar. Therefore, observations can be better explained only if log $S_L > 2$. The metallicity in log S_L = 2.9 models is in the range $-2.2 \lesssim$ [C/H] $\lesssim -1$, while the density spread is $-3.5 \lesssim \log n_H \lesssim -2.9$. A similar spread in metallicity is obtained for the log S_L = 3.5 models, whereas the upper limit to the density is log $n_H \lesssim -3.7$. Metallicities lower than 1/10 of solar found in this cloud, suggest ages lower than 1 Gyr. The size inferred by the calculations indicates that the cloud is smaller than typical clouds of the Lyα forest for which lower limits to the size have been found to be 70 kpc (for H_0 = 70 km s^{-1} Mpc^{-1}) at redshift $z \sim 2$ (Smette et al., 1995). The difference is also in the gas density which is always lower than the typical value of $n_H = 10^{-4}$ cm^{-3} found in the Lyα forest clouds. Thus we are still far from concluding that all the optically thin Lyα lines have the same intergalactic origin.

Metal systems optically thin to the HI ionising photons are an important probe of the shape of the UV background radiation. If this is the main ionising source, the quasar light contribution only absorbed by H I of the discrete Lyα clouds and Lyman limit systems (which implies log $S_l \sim 1.5$) cannot explain the observations. This means that either an additional source of ionisation is necessary, or intergalactic diffuse He II is responsible for the spectral shape of J_ν at wavelengths lower than 228 Å, or both. Further detailed analysis of $N_{\mathrm{HI}} \sim 10^{15}$ cm^{-2} absorption systems with metal lines will hopefully clarify this situation. Challenging results can be obtained by dedicated observations with 4-m-class telescopes and do not need to wait for the VLT to be operational.

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Optical Observations Provide a New Measure of the Vela Pulsar's Proper Motion

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1. Introduction

Isolated Neutron Stars (INSs) move in the sky with high (≥ 100 km s^{-1}) tangential velocities (Lyne & Lorimer, 1994). Indeed, proper motions have been measured for several INSs, mainly in the radio domain (Harrison et al., 1993). In addition, for two (possibly three) INSs proper motions have been measured in the optical domain through relative astrometry of their optical counterparts.

TABLE 1: This table summarises the published values of the Vela pulsar proper motion obtained from radio as well as optical observations.

	Optical			Radio	
	Bignami & Caraveo 1988	Ögelman et al. 1989	Markwardt & Ögelman 1994	Bailes et al.* 1989	Fomalont et al. 1992
μ	< 60 mas	38 ± 8 mas	49 ± 4 mas	59 ± 5 mas	116 ± 62 mas
μ_α		–26 ± 6 mas	–41 ± 3 mas	–48 ± 4 mas	–67 ± 20 mas
μ_δ		28 ± 6 mas	26 ± 3 mas	34 ± 2 mas	–95 ± 75 mas

*After correction for the motion of the Sun and for the rotation of the Galaxy they obtain μ_α= –40 ± 4 mas and μ_δ = 28 ± 2 mas.

These NSs are Geminga (Bignami et al., 1993), the Vela pulsar (Bignami and Caraveo, 1988; Ögelman et al., 1989; Markwardt and Ögelman, 1994) and, possibly, PSR 0656 +14 (Mignani et al., 1997). In the case of Geminga, because of its radio quietness, optical observations are the only way to measure such proper motion. In particular, proper-motion measures in the radio and optical bands are a valuable strategy to confirm optical identifications of pulsars that, in the optical domain, are far too faint for fast photometry observations (Mignani et al., 1997).

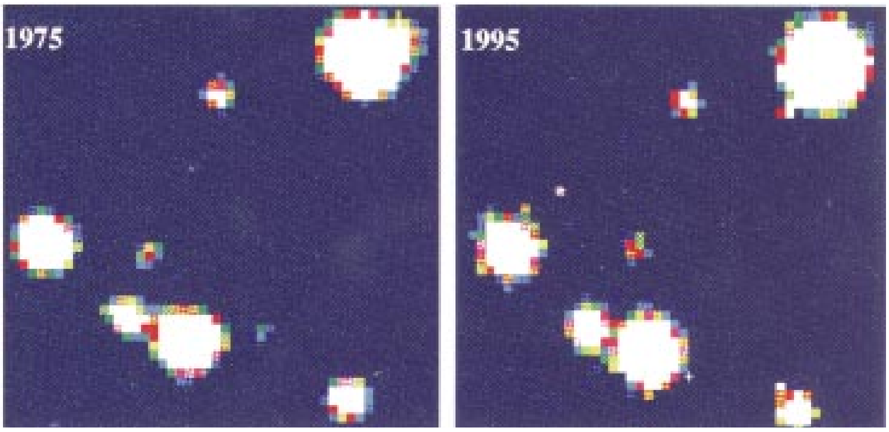

Figure 1: Images of the Vela pulsar field taken in 1975 with the CTIO 4-m and in 1995 with NTT/EMMI.

2. The Vela Pulsar

Optical observations represent a real alternative to measure proper motions since they are independent from timing irregularities. This is specially true in the case of the Vela pulsar, well known for its gigantic glitches. Indeed, a comparison between published values of the Vela pulsar proper motion shows significant differences between radio and optical measurements (see Table 1 for a summary) with angular displacements going from a minimum of 38 mas yr^{-1} (Ögelman et al., 1989) to a maximum of 116 mas yr^{-1}(Fomalont et al., 1992). Thus, although the Vela pulsar moves in the sky, the actual value of its displacement is still to be measured.

3. The Observations

For the measure of the proper motion we have used a set of four images collected over several years with the ESO telescopes, 3.6 m and NTT (see Table 2). To obtain a reliable measure of the pulsar's proper motion, we have selected only those images obtained in the Johnson's B filter. This overcomes shifts of the object's centroid induced by differential refraction of the Earth's atmosphere (Filippenko, 1982 and references therein). Our data set was later integrated by the original image, taken in 1975, which lead to the discovery of the Vela optical counterpart (Lasker, 1976). Since the 1975 image is recorded on a broad-band blue IIIa-J plate, it has been digitised in order to allow an immediate comparison with other, more recent images, taken with CCD detectors.

To compute the pulsar's proper motion, the different images have been rebinned and rotated in order to match exactly the same scale and orientation.

As a reference frame we used the most recent image of the field which is also the one obtained under the best seeing conditions (~ 0.8 arcsec). Rebinning and rotating were applied using the standard alghorithms available in MIDAS. After this procedure, all the reference stars were seen to overlap within a few hundredths of the reference pixel.

Table 2: Data set used for the proper-motion measure. The displacements of Vela are computed with respect to the 1975 frame. The quoted uncertainties include stars' centring errors as well as errors in the rebinning/rotation procedures.

Epoch	Telescope	Pixel size	Exp. time	$\Delta\alpha$	$\Delta\delta$
1975.2	CTIO 4-m	—	45 min.	0 ± 0.05	0 ± 0.05
1987.1	ESO 3.6-m	0.67″	30 min.	–0.46 ± 0.06	0.21 ± 0.06
1988.1	ESO 3.6-m	0.67″	30 min.	–0.52 ± 0.09	0.31 ± 0.05
1990.1	ESO NTT	0.26″	85 min.	–0.73 ± 0.05	0.40 ± 0.05
1995.1	ESO NTT	0.36″	30 min.	–0.92 ± 0.02	0.45 ± 0.02

4. The Proper Motion

Contour plots of all the images were later prepared in order to provide an immediate guess on the source's displacement (Fig. 2). As it is clearly seen from the figure, while the position of the reference stars does not change, the pulsar exhibits a displacement of about 1 arcsec to NE. The angular displacement of Vela was then computed using the 1975 position as starting point and fitting linearly the pulsar's position at the different epochs.

The resulting proper motion is

$$\mu_\alpha = -47 \pm 3 \text{ mas yr}^{-1}$$
$$\mu_\delta = 22 \pm 3 \text{ mas yr}^{-1}$$

for a total annual displacement of 52 ± 5 mas yr^{-1} with a corresponding position angle ~ 295°, which appears completely unrelated to the soft X-ray jet observed by Markwardt and Ögelman (1995) to protrude south from the pulsar.

5. Conclusions

Our measurements make a final case for the Vela pulsar proper motion to be around 50 mas/yr. Since our proper-motion study covers a period of 20 years, the present result can be

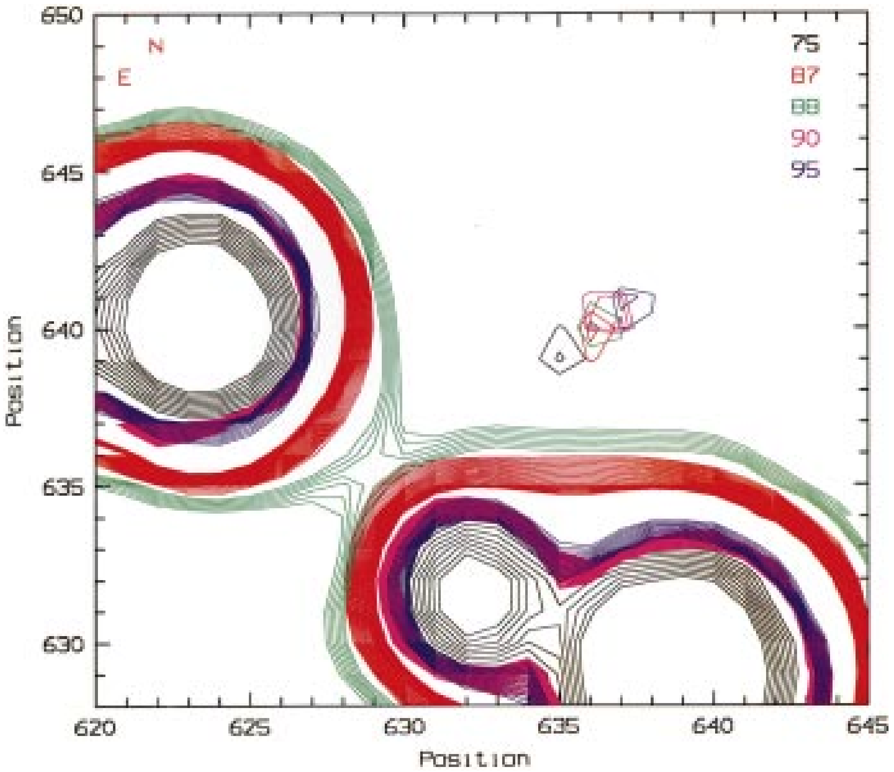

Figure 2: Contour plots of the five images available. While the position of the reference stars does not change, the overall displacement (~ 1 arcsec) of the Vela Pulsar over a time span of 20 yr is evident.

considered reliable. In particular, our value is compatible with the previous measurements of Markwardt and Ögelman (1994) and Bailes et al. (1989), while it is clearly incompatible with the ones of Ögelman et al. (1989) and Fomalont et al. (1992). A better assessment will only be possible through accurate HST astrometry, currently in progress, which could also yield a measurable annual parallax, ending the current debate on the Vela pulsar/SNR distance. Indeed, a reanalysis of ROSAT data by Page et al. (1996) suggests that the pulsar could be as close as 285 pc, while radio measurements (Taylor et al., 1993) provide a distance of ~ 500 pc.

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Bavarian Prime Minister at La Silla

In the afternoon of March 9, 1997, the Bavarian Prime Minister, Dr. Edmund Stoiber, on the invitation of the Director General of ESO, Professor Riccardo Giacconi, visited the ESO La Silla Observatory. The photograph shows the Prime Minister and Mrs. Karin Stoiber on the platform near the ESO 3.6-m telescope with the lower observatory area in the background.