The true nature of CSL-1.

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\textbf{ABSTRACT}

On January 12 of 2006, the Hubble Space Telescope (HST) observed the peculiar double extragalactic object CSL-1, suspected to be the result of gravitational lensing by a cosmic string. The high resolution image shows that the object is actually a pair of interacting giant elliptical galaxies. In spite of the weird similarities of the energy and light distributions and of the radial velocities of the two components, CSL-1 is not the lensing of an elliptical galaxy by a cosmic string.

\textbf{Key words:} cosmic string; galaxies; general; cosmology.

\section{1 \ PRE-HST OBSERVATIONS OF CSL-1}

The Capodimonte-Sternberg-Lens candidate n. 1 (CSL-1; $\alpha_{2000} = 12^h 23^m 30.5^s$, $\delta_{2000} = -12^\circ 38' 57''0$), a peculiar extragalactic object observed in the OACDF by Sazhin et al. (2003), hereafter Paper I, appears as a double source projected onto a low density field. The two components of the source are 1.9 arcsec apart, well resolved (i.e. extended) and,
when observed from the ground, show roundish and identical shapes. Low resolution spectra look identical with a high confidential level (c.l.) and both give the same redshift of $0.46 \pm 0.008$. Photometry matches the properties of giant elliptical galaxies. Additional medium-high resolution observations carried on with FORS1 at VLT in March 2005 confirmed the similarity of the spectra of the two objects at a 98% c.l. \textit{Sazhin et al.} (2005) and showed that the differential radial velocity is compatible with zero $\pm 20 \text{ km s}^{-1}$.

In view of all that, already in Paper I we argued that CSL-1 could be either \textit{i)} the chance alignment of two very similar giant E galaxies at the same redshift, or \textit{ii)} a gravitational lensing phenomenon. In this second case detailed modelling shows that the properties of CSL-1 are compatible only with the lensing of an E galaxy by a cosmic string.

Cosmic strings were first introduced by \textit{Kibble} (1976) and extensively discussed in the literature (cf. \textit{Zeldovich} (1980) and \textit{Vilenkin} (1981)). Recent work has also shown the relevance of cosmic strings for both fundamental physics and cosmology (cf. \textit{Davis & Kibble} (2005)) and has shown that cosmic strings could be observable, in principle, via several effects, the most important being gravitational lensing, as we extensively discussed in the above quoted papers.

Is CSL-1 a cosmic string? In Paper I, we suggested an \textit{experimentum crucis} \textit{(Sazhin et al.} 2003\textit{):} the detection of the sharp edges at faint light levels which are expected to be generated by a cosmic string (Fig.1). This test requires high angular resolution and deep observations to be performed with the Hubble Space Telescope (HST). In what follows we shortly summarise the most immediate outcomes of these observations.
2 THE DATA

The observations were performed on January 11 2006 with the ACS camera. CSL-1 was observed for 6 HST orbit in the F814W band (comparable to Johnson-Cousins I-band) yielding an effective exposure time of $\sim 14000$ seconds. The observations were performed adopting a 1/3 pixel dither pattern, to allow sub-pixel sampling of the HST PSF and cosmic ray rejection. All 6 orbits were combined through the Multidrizzle software (Koekemoer et al. 2002) using a 1/2 pixel (0.025 arcsec/pixel) resampling pattern. In what follows we shortly summarize the main results.

3 THE HST IMAGES

Figure 1 shows the region surrounding CSL-1 as observed by the ACS Wide Field Camera on board of HST. The faint isophotes of the two components have different shapes, which is incompatible with CSL-1 being a cosmic string, and the expected sharp edges are not present. In the cosmic string scenario all morphological features of the source falling inside the deficit angle, would be mirrored on the opposite side of the string. However in the HST image we do not see such mirroring effect for the two components, nor for any other faint feature which, would have fallen inside the deficit angle of the string and should have been duplicated, e.g. the faint sources on the southern side of CSL-1 visible in the right panel of Figure 1.

Another test, proposed and discussed by several authors (Vilenkin, Shellard 1994; Hindmarsh 1990; Huterer & Vachaspati 2003; Sazhin et al. 2004), takes into account the fact that the alignment of the background object (a galaxy) inside the deficit angle of the string is a stochastic process determined by the area of the lensing strip and by the surface density distribution of the extragalactic objects which are laying behind the string. All objects falling inside the narrow strip defined by the deficit angle computed along the string pattern should be affected and, the deeper the image, the larger the number of gravitationally lensed images to be expected.

In Fig.2 we present the image of the whole field, produced by stacking the 6 HST orbits. Our careful examination of the source population around CSL-1 reveals no overdensity of galaxy pairs with separations $< 2''$. The lack of such galaxy pairs in our image (aside from CSL-1) therefore leads to a strong rejection of the cosmic string hypothesis.

For completeness we also fit the two objects with two de Vaucouleurs $r^{1/4}$ light profiles
and subtract the model from the original data. The residual image, presented in Fig. 3, clearly shows the presence of warped structures in the CSL-1 outskirts, probably tidal tails due to the interaction between the two galaxies.

As a result of our observation, we have therefore to conclude that CSL-1 is not the lensing of an elliptical galaxy by a cosmic string.

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Figure 3. The normalized residuals (residuals/model) obtained by subtracting from the HST images a model consisting of two de Vaucouleurs light profiles.

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