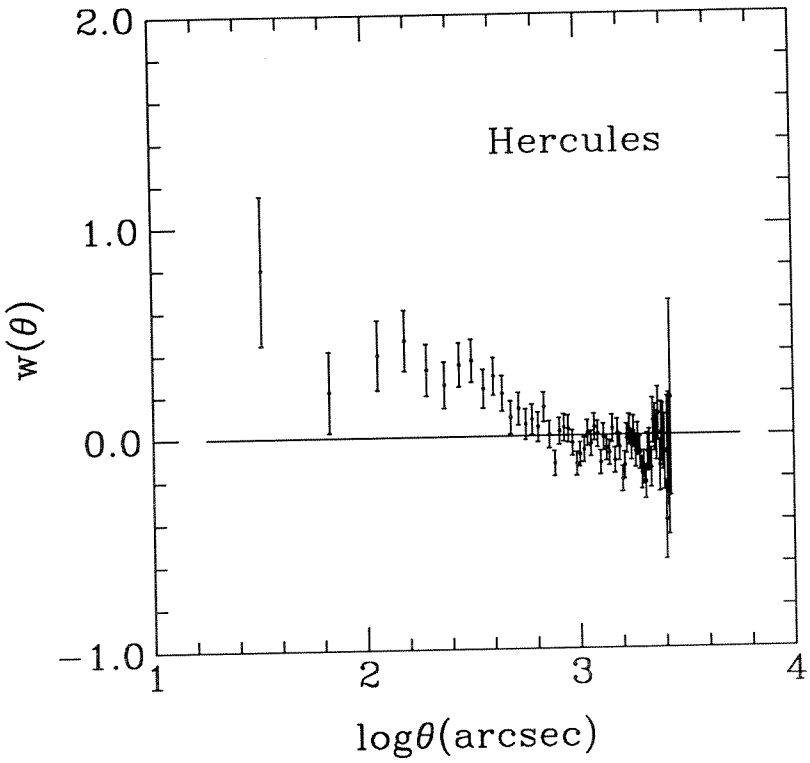

Figure 22: The two-point angular correlation function w(Θ), for the galaxies in the field of the Hercules Cluster (from the photometry of Butcher and Oemler 1985). The mean separation for pairs in the first bin is 32.5 arcsec.

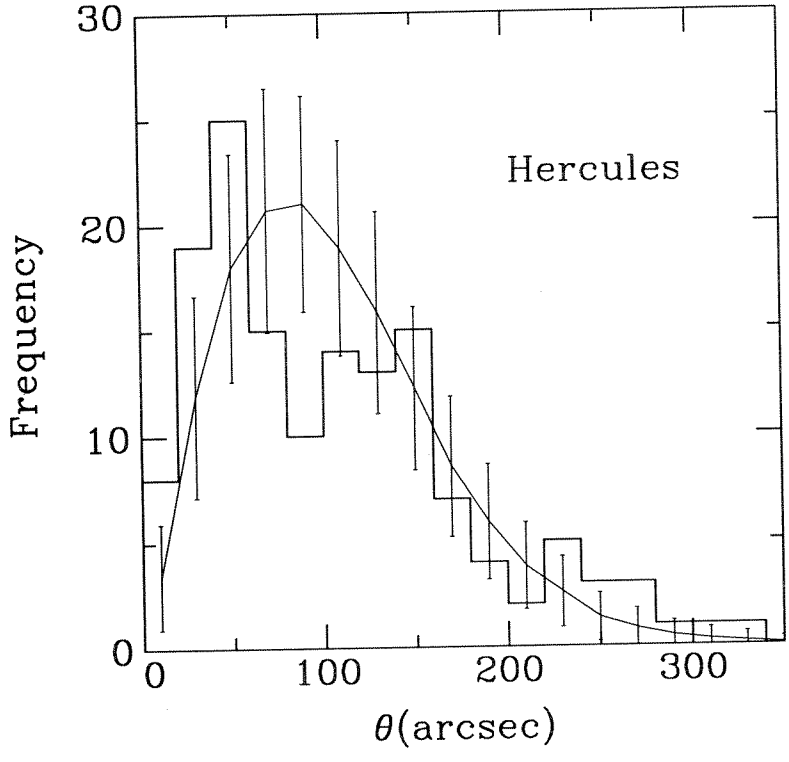

Figure 23: The distribution of nearest neighbors for the galaxies in the Butcher, Oemler (1985) field of the Hercules cluster. The histogram is the observed distribution, while the solid curve and error bars illustrate the mean and 1 standard deviation from 500 random simulations. The enhancement at 50 arcsec and smaller separations is evident.

GHO 0020+0407 bears many of the same characteristics as the well studied Hercules Cluster, both clusters being populated predominately by disk systems, and lacking a central concentration of giant ellipticals. It is well known that the Hercules Cluster has a number of close pairs with morphological distortions indicative of strongly interacting systems. We might ask, therefore, whether Hercules exhibits a statistically significant excess of close pairs, as we found for GHO 0020+0407. Figure 22 shows the angular two-point correlation using the catalog of Butcher & Oemler (1985) for Hercules. We find a similar excess of close pairs!

Our HRCam image from CFHT (FWHM = 0.42 arcsec) of GHO 0020+0407 (z = 0.698) has been used to examine the statistics of subclustering in this cluster of galaxies. Using both the two-point angular correlation function, w(Θ), and the distribution of nearest neighbors, we have quantified the frequency of strong interactions and mergers at z = 0.7 (a look-back time of ~ 0.4 T_o). We find an enhancement at small separations by nearly a factor of three over what would be expected given a random distribution within the cluster. The typical angular separations are 1 – 1.5 arcsec, corresponding to spatial separations of about 12 kpc, depending on H_o and q_o. Given that such close pairs and groups are likely to merge on timescales of about <.1 Gyr, and that the luminosities of some pairs reach up to ~ L*, it seems likely that the resulting systems will be identified as elliptical galaxies by z = 0.3 – 0.4.

The cosmological significance of such strong interactions and mergers in the evolution of rich clusters is obviously still uncertain, but it is very interesting that a similar process appears to be occurring at the present epoch in the Hercules Cluster. Thus we conclude that interactions and mergers in rich clusters are likely related to the dynamical evolutionary state of the cluster at the particular epoch of observations. Albeit, clusters at high z may be more likely to be in the earlier stages of evolution characterized by the loose subclustered morphology favorable to strong interactions and mergers.

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Optical Identification of a New Einstein Cross & Discovery of the Deflecting Galaxy

Q1422+231 has been discovered at VLA during a new survey of 1750 flat-spectrum radio sources (from 5 to 8.4 GHz). Radio observations have revealed its very unusual morphology since the source was made by 4 unresolved components within 1.3 arcsec, while flat spectrum radio source generally consists in a single unresolved component.

Q1422+231 was then proposed as a new gravitational lens, both from its morphology and the fact that each component have the same radio spectral index (Patnaik et al, 1992, MNRAS, 259, 1p).

We have observed Q1422+231 the 21st March 1993, having FOCAM at the prime focus, with the RCA2 chip (0.2"/pixel), under good seeing conditions (FWHM= 0".65). Both in V and I we have been able to identify the 4 components detected at radiowavelengths.

Thanks to this good image quality and to a good signal to noise ratio, we applied some angular resolution enhancement processes, namely a Lucy deconvolution and a maximum entropy deconvolution. We used as a PSF a nearby star. Both restaured images clearly show the 4 components. Figure 1 (cover) displays the result of the maximum entropy deconvolution. However, these methods are non linear and do not provide accurate photometry. To derive precise positions and flux of the components, we used the casual method of PSF subtraction, with 4 components, letting the positions and flux as free parameters to minimize the residuals.

The resulting positions are within 0.02" of the position given by Patnaik et al, with an accuracy of 0.02". The relative intensity (relative error 0.08) are close to the one derived from the radio observations, with a slight deficiency for component B (20%) that we are still investigating. The subtraction of the 4 components revealed a fifth object (at about 6 sigma above noise), close to component D, extended, which is at the location expected for the deflecting galaxy. The fact that this component is almost as bright as component D in optical (magnitude I=21), while it is not detected at radio wavelengths also supports this interpretation. Figure 24 shows the location of the 4 quasar images and of what is assumed to be the deflecting galaxy.

This peculiar morphology of the mirage is probably due to an accurate alignment between a very luminous QSO at z= 3.65, and a foreground elliptical galaxy at a moderate redshift (0.1-0.6). The dark matter in the lensing galaxy (including its halo) should follow a very elliptical distribution to form such a system, which resembles to the well-known Einstein Cross (Q2237-0305, a four multiplied imaged QSO by the bulge of a nearby galaxy). Model of this Q1422+231 will provide new and interesting constraints on the mass distribution in massive galaxies and their haloes. It also might be a good candidate to be surveyed for its (short) time delay because it is bright both at optical and radio wavelengths, and also since it appears to be a rather simple lensing configuration.

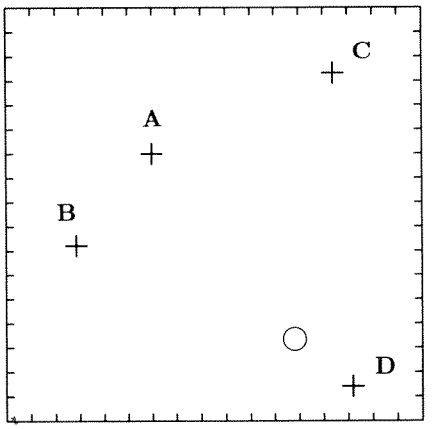

Figure 24: Location of the components (crosses) as derived from the I image. The circle points the fifth object (deflecting galaxy). One graduation is 0.1". North is left, East is down.

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