ARCS IN X-RAY SELECTED CLUSTERS

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Abstract

We present results from an imaging survey carried out at the University of Hawaii to search for gravitational lenses in X-ray selected clusters of galaxies. We have imaged 41 clusters extracted from the *EMSS* in two colors, and we have found 8 giant arcs and a similar number of mini-arcs and/or candidates. Spectroscopy is needed to confirm the gravitational lensing hypothesis.

1. Introduction

Deep imaging with *CCD*'s has revealed that clusters act as gravitational lenses producing distorted and magnified images of background galaxies. Arc redshifts are systematically measured to be greater than the cluster redshifts[1,2] and very similar to those of galaxies found in deep redshift surveys. This fact, combined with the symmetry and locations of the arcs, confirm the gravitational lensing idea. As the physics of the lensing is understood, we may use the properties of the arcs to probe the mass distribution in rich clusters. Another promising field of investigation is the study of the properties of very distant normal galaxies which are the "source" of the lensing. The determination of their redshifts would be otherwise impossible with present day technology. A large number of clusters needs to be observed to derive global properties of either the lens or the sources and large amounts of telescope time need to be allocated for both imaging and spectroscopy. A high efficiency procedure to search for arcs is then required.

2. The Hawaii Arc Survey results

We have been involved in an observational program to image in B and R a sample of 41 of the highest X-ray luminosity *EMSS*[2,3] clusters ($L_x > 2 \times 10^{44}$ ergs/s) with redshifts $z > 0.15$ in order to search for gravitational lensing. We assume that the hot, X-ray emitting gas is a tracer of the total gravitational potential of the cluster, both visible and dark matter. High X-ray luminosity is therefore a sign of a deep potential well and thus is an indicator of a true massive cluster, likely to exhibit the lensing phenomenon.

Of the 41 clusters in our sample, 8 contain spectacular "giant arcs" ($l > 10"$) and 9 more contain arclets or arc candidates. The high incidence of lensing obtained (at least 29%) is a better success rate than achieved with surveys of optical selected clusters[5,6]. The lensing frequency and the thinness of the arcs, are strong evidence for compact mass density profiles for the lensing clusters. We have completed the imaging part of the survey and are concentrating now on obtaining spectra of the newly discovered arcs with the *CFH* and the Keck telescopes. We present here the results of the imaging survey which was carried out in excellent seeing conditions, using the University of Hawaii 2.2m telescope equipped with a Tektronix 2048 × 2048 *CCD*. Figure 1 shows a mosaic for the 7 of the 8 giant arcs. The top right *CCD* image is a 2-hour long exposure of the cluster MS0451.6−0305 which, at a redshift of $z = 0.55$, is the most X-ray luminous cluster source known ($L_x(0.3 - 3.5) = 2.0 \times 10^{45}$ ergs/s [$H_0 = 50$; $q_0 = 0.5$]. This value is 1.4 times the X-ray luminosity of CL0016+16, the archetypical high redshift X-ray cluster. In our recent 2.2m run we discovered a giant arc in the core[7]. Also worth mentioning is the cluster MS0302.7+1658 (top left). The "straight" arc in this *EMSS* cluster at $z = 0.424$ was discussed in Mathez et al. 1992 [8]. In our deep images taken on the *UH* 2.2m telescope, the straight arc is seen as the brighter, eastern extension of a long structure visible between the two bright galaxies. Another arc is seen to the south of the brightest galaxy. Spectroscopic determination of the redshifts of the brightest arcs is the next step in this study. *HST* and *ROSAT* data of the lensed clusters will also be obtained.

3. References

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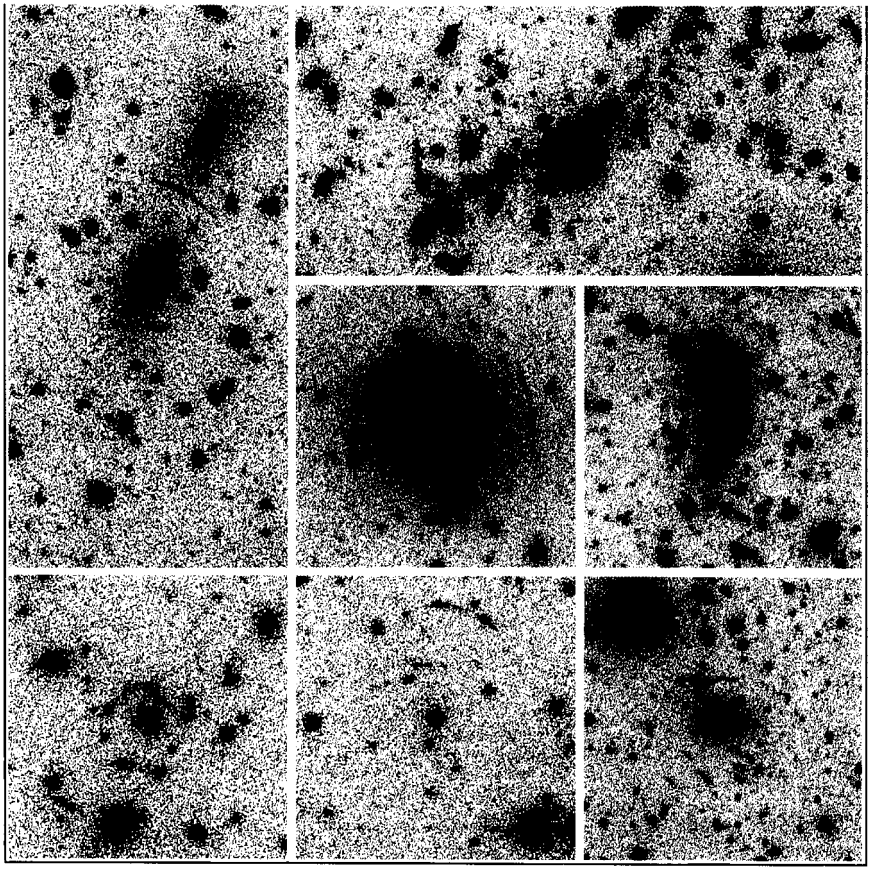

Figure 1 - CCD mosaic of seven EMSS clusters with gravitationally lensed arcs.