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Searching for Lyman Alpha emission from a possible Zel'dovich "pancake"

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Introduction

Uson, Bagri and Cornwell (1992) have reported the detection of 2×10^{14} $M_\odot$ of neutral hydrogen at a redshift of 3.397. Top-down theories of structure formation predict such a mass of hydrogen collapsing to form a protocluster of galaxies. We sought to observe this object in Lyman-α, which could be produced through ionization by the metagalactic ionizing radiation field or through internal ionization processes.

Observations

On April 29, 1992, we observed the region of the reported HI emission for 1800 seconds with the 1.3 meter McGraw-Hill reflector at Michigan-Dartmouth-M.I.T. Observatory. Because the HI emission reported by Uson *et al.* has a transverse scale of 300", we used a 1/3.06 reducing camera and a Thomson CCD to obtain a field of view of about 600" by 840". We used a filter 88 Å wide, centered at 5354 Å; Lyman-α emission at z=3.4 is redshifted to 5347 Å.

In order to avoid saturating the CCD with a bright star in the field, nine 200 second exposures were taken. The combination of these images shows no obvious extended Lyman-α emission at a level of about 28 magnitudes per square arcsecond.

The field we observed also shows a distant cluster of galaxies. In order to determine if the cluster could in any way be associated with the cloud of neutral hydrogen at z=3.4, we sought to estimate its redshift from the size and magnitude of the galaxies and of the cluster as a whole. We adopted Ω= 1 and H_0= 50 km s^{-1} Mpc^{-1}; our redshift estimates range from z=0.2 to z=0.6. The cluster is clearly not associated with the HI cloud at z=3.4

Analysis

We calculated the Lyman-α luminosity of the pancake assuming that there is no internal source of ionizing radiation but that it absorbs ionizing photons from the metagalactic radiation field (Donahue and Shull 1989). This resulting surface brightness is about 31 magnitudes per square arcsecond. Consequently, unless this object does have an internal source of ionizing radiation, it will be difficult to detect optically. There would be internal ionizing radiation if the pancake had collapsed sufficiently to produce star formation.

Uson *et al.* find that the HI cloud has a transverse scale of 300" but do not report the position angle; consequently we considered a circle 300" in diameter centered on the reported coordinates when we attempted to establish an upper limit to the flux reaching us from the HI cloud. We established 16 detection cells within the 300" circle and compared these cells with 16 cells from other parts of the frame. This is illustrated in Figure 1. We endeavored to avoid including stars or excessive noise (such as that due to the CCD bleeding in response to saturation by bright stars) in any of the cells. We find a nominal detection, but it is at a very low level; about 1.2 σ. This 1.2 σ detection corresponds to 18th magnitude, or 2.07×10^{-14} erg s^{-1} cm^{-2}, over the whole 16 cell detection region. In this region a 3 σ upper limit corresponds to about 17 magnitudes, or a flux of 5.16×10^{-14} erg s^{-1} cm^{-2}. This is equivalent to a luminosity at the source of 4.7×10^{45} erg s^{-1}. The Lyman-α flux expected to reach us from a Zel'dovich pancake at a redshift of z=3.4 is 3.2×10^{-15} erg s^{-1} cm^{-2}. Our calculations of the Lyman-α luminosity of an HI cloud with no internal source of radiation yield a Lyman-α luminosity of about 2.9×10^{44} erg s^{-1}.

There is a factor of three uncertainty in the strength of the metagalactic ionizing radiation field. If it were a factor of 3 more intense than the 10^{-21} erg s^{-1} cm^{-2} Hz^{-1} sr^{-1} assumed in our calculations, then a Zel'dovich pancake at z=3.4 could be detected in one night of observing at the MDM 1.3 m telescope. The observations reported here were limited to half an hour due to poor weather. We intend to dedicate more observing time to this object in the future.

References

Uson, J. M. , Bagri , D. S., and Cornwell, T. J. 1992, *Phys. Rev. Letters*, **67**, 3328.

Donahue, M. and Shull J. M. 1989, *Astrophys. J.*, **383**, 511.

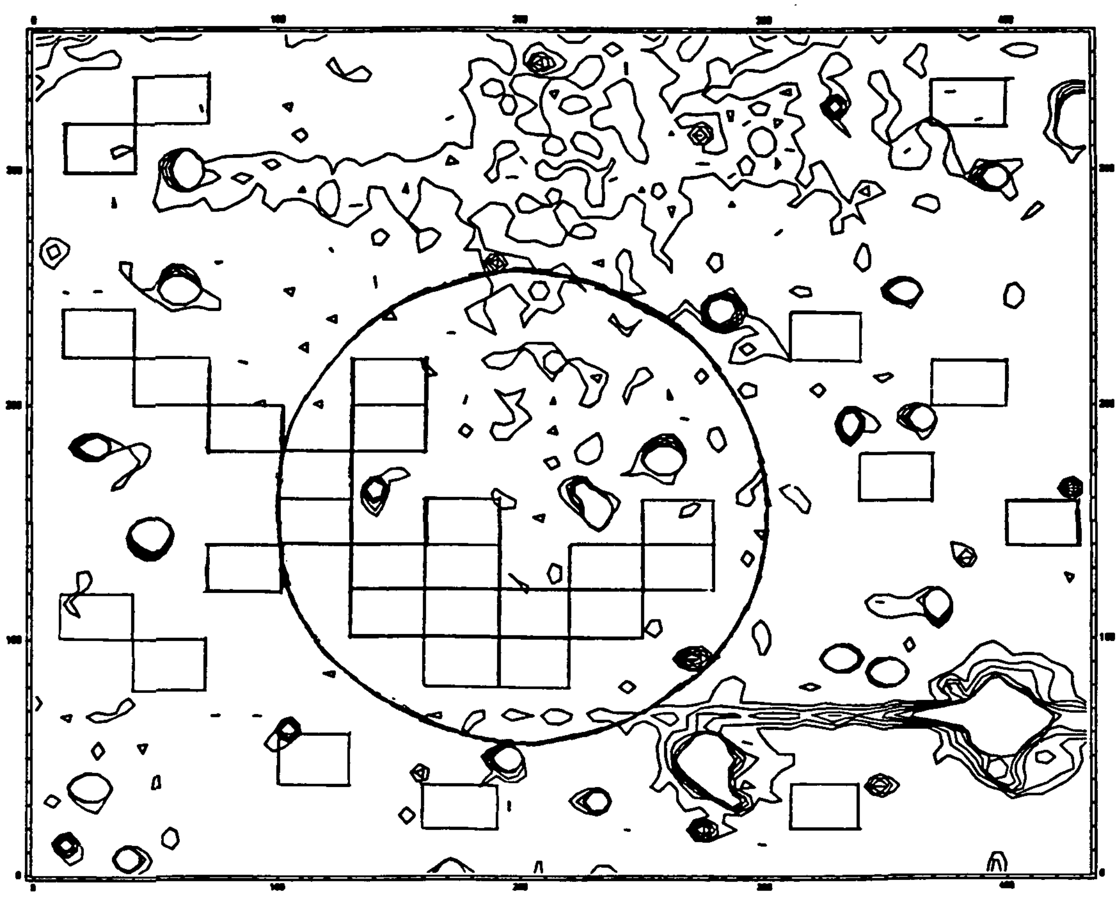

Figure 1

Contour plot showing 300" diameter circle centered on 0904+3352. The 16 detection cells within the circle were compared with the 16 detection cells outside the circle in order to determine the flux level.