LYA AND IR GALAXY COMPANIONS OF HIGH REDSHIFT DAMPED LYA QSO ABSORBERS

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1. The ancestors of the present-day galaxies

It is true today that not much is known with a solid observational support about the origin and the formation of the present-day gas-rich galaxies. For astronomers, finding our Galaxy ancestor at look back-times of 10 billion years or more would be as thrilling as it has been for paleontologists finding "Lucy" the 4 million years old human ancestor. However, because of galaxy evolution, it will be difficult to recognize the true Galaxian ancestor. A priori, there is no reason for all young forming galaxies to be radio-loud galaxies or even quasars. But the galaxies must form the bulk of their stars at high redshift, with star formation rates (SFR) 10 to 100 times higher than those observed in present-day galaxies. Current SFRs are typically 1 $M_{\odot}$/yr, much too low to produce the stellar mass of galaxies in the Universe lifetime. Intense emission lines Lyα, [OII]λ3727 Å, [OIII]λ5007 Å, Hβ, Hα are predicted to be characteristic signatures of the protogalaxies which are conjectured to be large, massive protogalactic disks with supergiant clouds of ionized gas. The interstellar medium of the protogalaxies is likely to be turbulent, as a result of the considerable energy input from frequent supernovae explosions. A copious amount of dust could be well mixed with the gas and the stars, that absorbs direct stellar light, causes significant scattered light and converts optical stellar light into thermal infrared emission from hot dust.

2. An Infrared Survey of QSO absorption line systems at high redshift

The predicted strong emission lines ([OII], O[III], Hβ, Hα) emitted by young forming galaxies will be redshifted in the infrared J, H, or K bands, at z>1. These lines will be much less extinguished by dust than Lyα, if there is any dust in the primeval galaxies, as Lyα photons are scattered and absorbed by grains within the HII regions (Spitzer 1978). A year ago, we started an IR imaging survey to detect the high z galaxies responsible for the population of QSO heavy-element absorption line systems between z=1.3 and 2.5. The survey samples objects drawn for a more representative portion of the galaxy-luminosity function than the high z radio galaxies and QSO companions where physical conditions are abnormal, perhaps due to their proximity to an active nucleus. The survey extends, in the IR and at higher z, the optical imaging surveys that identified the galaxies producing the QSO Mg II absorption lines at z<1. The low z absorbers are galaxies with star formation activity as evidenced by strong extended [OII] emission and blue continua (Bergeron 1986; Yanny, York, and Williams 1990; Yanny 1990). Unless the low z absorbers are shrouded by dust, their moderate SFRs imply higher SFRs in the more distant absorbers at z>1 to produce all stars in present-day galaxies.

We have used a NICMOS3 HgCdTe 256x256 array detector with the IR camera built by Marcia Rieke on the 2.3m telescope at Steward Observatory to image several QSO fields. The limiting magnitude is K'(2.1μm)= 21.0–21.5 mag per square arcsec for a 3 sigma detection in 3 hours of in-field chopping observations. Each QSO line-of-sight samples several known absorbers with MgIIλ2796–2803 Å and/or CIVλ1548–1551 Å absorption doublets. The equivalent width distributions of the low and high ionization absorption lines of the absorber sample are identical to those of the parent population of all absorbers. This selection process, used already for a spectroscopic survey of MgII absorption lines in CIV-selected absorption systems at high z (Caulet and York 1986, Caulet 1989), gives a methodical approach to observing, reduces the observer biases and makes a more efficient use of telescope time. This selection guarantees that imaging of the sample of QSO fields will provide complete sampling of the whole population of high z QSO absorbers. Included in the sample, the highly ionized, optically thin CIV absorbers (with weak or no MgII absorption) and the high column HI density damped Lyα systems represent both extremes of the ionization states and of gas density in the QSO heavy-element absorbers, and have never been successfully imaged without ambiguity. The high z damped systems are the "best bet" candidates of the protogalactic disks that evolved into our Galaxy and the other present-day spirals (Wolfe et al. 1986).

Figure 1 is the 5 hour exposure K' image resulting from the combination of a mosaic of 558 individual frames. It shows a candidate z=2.3 cluster of galaxies. One of the galaxies had been discovered previously in Lyα emission with the NASA/GSFC Fabry-Perot Imaging Interferometer during our optical imaging survey of damped Lyα systems (Caulet et al. 1990, Lowenthal et al. 1991). With z=2.313, the Lyα emitting galaxy is a galaxy companion of the z=2.309 damped Lyα system which has been detected only spectroscopically in absorption on the line of sight of the QSO PHL 957. The other small objects clumped around the Lyα galaxy are new candidate galaxies detected in the K' band. We identify also, in the same K' image and near the QSO line of sight, several new galaxy candidates for the damped Lyα system and other intervening QSO absorption systems between z=2 and 3. Follow-up optical and IR spectroscopy of these objects is scheduled for redshift measurement and confirmation of the absorbing galaxies and the cluster members.

References

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Figure 1: K image of PHL 957 field