Hα DOTS

Faint Emission-Line Objects Discovered in Narrow-Band Images

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Abstract

Hα dots are extragalactic emission-line sources recently discovered in images taken as part of a narrow-band Hα survey. We present results from the first 60 Hα dots detected. Based on follow-up spectra, we determined that the Hα dots are a combination of (1) low-luminosity star-forming galaxies, (2) isolated extra-galactic HII regions, and (3) background objects where another strong emission-line, such as [OIII]λ 5007, has redshifted into the Hα filter. The background objects are a combination of star-forming regions and AGN. Some of the low-redshift star-forming Hα dots are metal poor (with metallicities as low as log(O/H)+12=7.62). The Hα dots can add to our understanding of the formation and evolution of low-luminosity galaxies.

Finding Hα Dots

- We noticed isolated, compact regions of emission in narrow-band images taken for the ALFALFA Hα project. Figure 1 shows two example Hα dots.

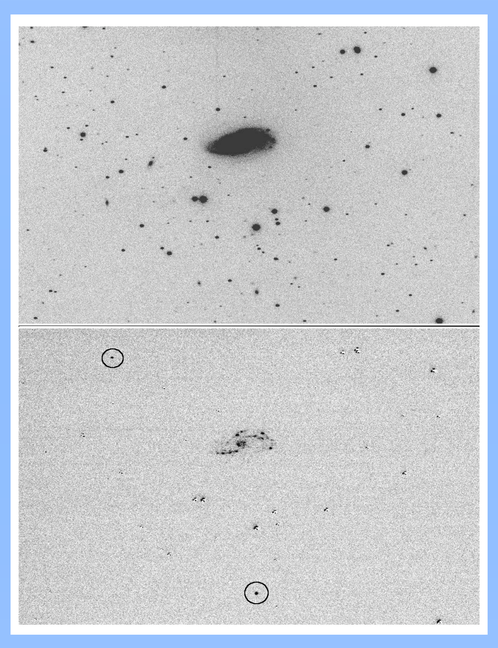


Figure 1: The top panel shows the R image and the bottom panel shows the continuum-subtracted Hα image of a spiral ALFALFA galaxy. The Hα dots, which are circled, appear to be separate from the ALFALFA galaxy (Kellar et al. 2008).

- In order to find more Hα dots, we wrote software to systematically search all of our images.

- Objects that have significant Hα emission and small magnitude errors are selected as Hα dot candidates.

- We searched 205 Hα images, covering 11.7 square degrees, and found 60 Hα dot candidates (See Figure 2).

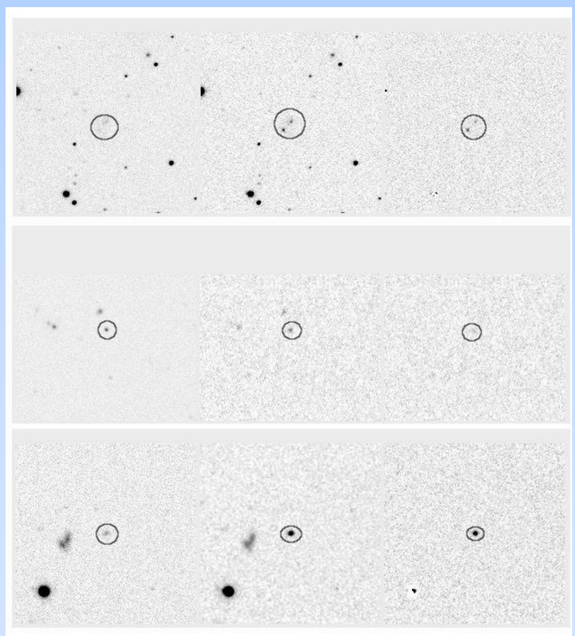


Figure 2: Example Hα dots. Each panel consists of three 200 by 200 pixel cutouts centered on the Hα dot from the R, Hα, and Hα continuum-subtracted images (from left to right).

What are Hα Dots?

- In order to determine the nature of Hα dots, we obtained spectra for all 60 Hα dots using the MDM 2.4m telescope and the Hobby-Eberly telescope (See Figure 3).

- 29 are low-redshift galaxies (z=0.0059 to z=0.024). 22 are background objects (z=0.32 to z=3.3), where another strong emission line redshifted into the Hα filter. Nine are not emission-line galaxies, but are false detections.

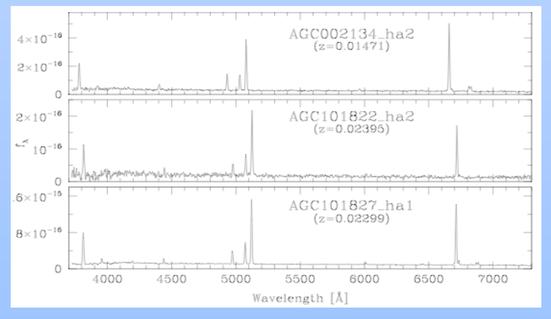


Figure 3: Example spectra of low redshift Hα dots (top three panels) and high redshift Hα dots (bottom three panels).

- We use emission-line ratios to distinguish between star-forming regions and AGN (see Figure 4). All 29 of the low redshift Hα dots are star-forming regions. The 22 high redshift Hα dots are a combination of star-forming regions (12) and AGN (10 including the 4 quasars).

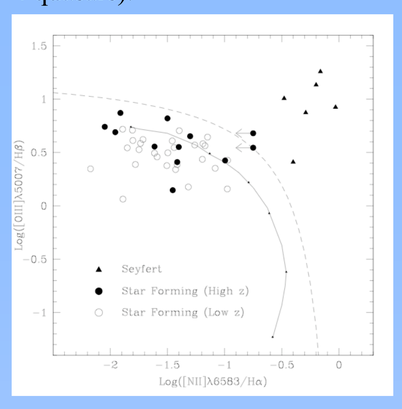


Figure 4: Emission-line ratio diagnostic diagram for the Hα dots. Star-forming regions are distinguished from AGN using a theoretical model from Dopita and Evans (1986; solid line) and a dividing line from Kauffmann et al. (2003; dashed line).

Recently Formed Galaxies?

- We use the [OIII]/Hβ and [NII]/Hα ratios to estimate the oxygen abundances for the star-forming Hα dots using a course abundance method (Salzer et al. 2005).

- The majority of Hα dots have oxygen abundances log(O/H)+12 less than 8.00 (less then 15% solar).

- Both the Hα-detected and [OIII]-detected Hα dots have a mean metallicity of 7.91.

- The [OIII]-detected Hα dots are particularly interesting because they are extremely metal poor for their luminosity (see Figure 5).

- These luminous, but metal-poor, objects could represent a population of recently formed galaxies at z≈0.33 (Salzer et al. 2009).

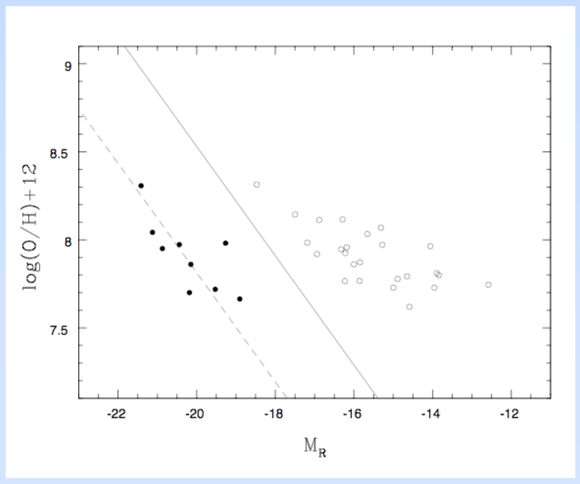


Figure 5: Luminosity-Metallicity (L-Z) diagram. The low redshift Hα dots are plotted with open circles and the high redshift Hα dots are plotted with filled circles. The solid line is the fit to the KISS low redshift galaxies, and the dashed line is a fit to the KISS high redshift galaxies (Salzer et al. 2009).

Low-Luminosity Galaxies

- The Hα dot survey gives us the opportunity to study the properties of star-forming galaxies which have log Hα luminosities ranging from 38.54 erg s^{-1} to 40.8 erg s^{-1} (see Figure 6). These galaxies lie at distances ranging from 24.5 Mpc to 108.3 Mpc.

- For these low-luminosity galaxies (the low-redshift Hα dots), there appears to be a flattening in the L-Z relation (see Figure 5). This suggests that the L-Z relation may not be linear at low luminosities.

- The star-formation rates of the low-redshift Hα dots range from 0.0027 M_{sun} $year^{-1}$ to 0.50 M_{sun} $year^{-1}$.

- The ability of the Hα dot survey to detect objects with Hα fluxes as low as 6.10 x 10^{-16} erg $s^{-1}cm^{-2}$ suggests that the narrow-band imaging technique and Hα dot software are very sensitive (see Figure 7).

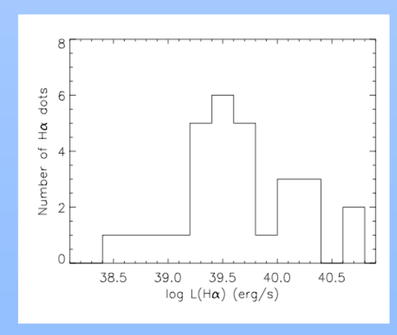
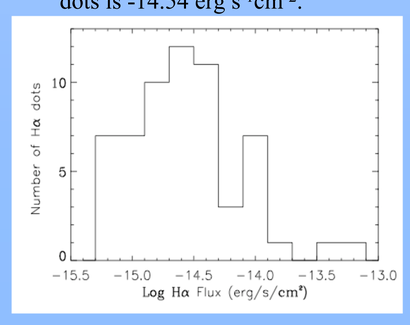


Figure 6: Histogram of the log Hα luminosities of the low-redshift Hα dots.

Figure 7: Histogram of the log Hα fluxes for all Hα dots. The median log Hα flux of the Hα dots is -14.54 erg $s^{-1}cm^{-2}$.



Environment

- The majority of low redshift Hα dots have velocity differences between them and the nearest ALFALFA galaxy of less than 200 km s^{-1} (see Figure 8). Physical separations between the majority of low redshift Hα dots and the nearest ALFALFA galaxy are less than 3 Mpc (see Figure 9).

- The velocity differences and physical separations suggest that there is a connection between most of the low redshift Hα dots and the nearby ALFALFA galaxies.

Figure 8: Velocity Difference

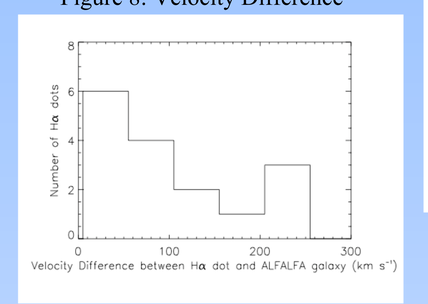
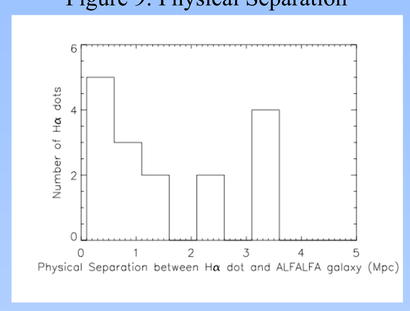


Figure 9: Physical Separation



Summary & Future Work

- The Hα dots are a combination of low redshift low-luminosity galaxies and background objects.

- The Hα dot survey is an ongoing survey.

- Finding more Hα dots will allow us to more fully understand the formation and evolution of these unusual galaxies.

References

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