Starburst Ages in HII Galaxies

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Introduction

The age of the starbursts of a few HII galaxies is derived from optical photometry and compared with previous results from radio continuum spectra. HII galaxies are gas rich and characterized by the dominance of giant HII regions, blue stellar colors, high surface brightness and narrow emission lines. The presently observed high abundances of bright young stars must be the result of a recent -or even ongoing- starburst. The question, whether the observed starburst is the first one or if it is a recurrent phenomenon, is still open. If the starburst is the first one, HII galaxies can be interpreted as being among the most unevolved galaxies known - their star formation characteristics possibly paralleling that of normal galaxies early in their evolution.

The optical data

A sample of five HII galaxies was observed with B,R and I broadband filters at the University of New Mexico's Capilla Peak observatory. They have been observed previously at several radio continuum frequencies (Deeg at al., 1992, submitted to ApJ). The photometric data are given in the Table. All colors given are corrected for galactic extinction. It should be noted, that II Zw 40 has an unusually large correction for galactic reddening of E(B-R) = 1.02, whereas this correction is 0.1 or less for all other galaxies.

Results of the photometry

B-R colors bluer than the color of the disk (which is assumed to be between 0.95 to 1.6) are indicators of star forming activity within time scales of 10^9 years. From the literature (e.g. Thuan and Martin 1981, ApJ, 247, 823, or the RC3) U-B color indices can be obtained. Color-color diagrams are frequently used to derive star formation histories in galaxies by comparison to colors obtained in stellar synthesis models. Using these two color indices, the stellar synthesis models by Krüger et al. (1991, A&A, 242, 343) allow estimates of the burst strengths, b, and the time *since* the star burst, T_b (see table). The burst strength b is defined as the ratio of the total mass of stars formed in the burst over the total mass of stars ever formed. The length of the burst itself, is relatively short and assumed to be $5 \cdot 10^6$ years. The models depend mostly on the low mass cut-off, which was taken as $\sim 4\ M_\odot$. The other, but not so crucial parameter, is the amount of starformation in the underlying disk, which is assumed to be exponentially decaying with a time scale of 10^9 years; the starburst is occuring after 15 Gyrs. The influence of possible earlier starforming episodes on the colors of the current starburst is insignificant. It would be interesting to apply the generally bluer values of the cores ($B-R_{core}$) to the synthesis model; however, correspondingly detailed U-B colors are not yet known.

Comparison with radio-continuum spectra.

A majority of the objects in the sample have radio spectra which show a remarkable flattening at low frequencies (See Deeg et al., 1992). The flattening may be caused by several mechanisms, which are inherent to the special environment within these galaxies, such as high gas densities, large HII regions and the transient character of the peak starburst activity, after which the relativistic electrons are losing their energy within a few times 10^7 years. However, the two most likely mechanisms cannot be isolated with certainty, based on the radio spectra alone. They are free-free absorption of electromagnetic radiation in ionized HII regions and 'synchrotron aging', which describes the influence of the energy loss of relativistic electrons onto the radio-spectrum. Synchrotron aging allows an estimate of the age of the relativistic electrons, T_{syn} (see Table 2), i.e. of the time since the electrons were injected into the ISM . The ages T_{syn} are much less than those from the stellar synthesis, T_b (see the table below). T_{syn} depends on a galaxy' magnetic field as $B^{-3/2}$. Equipartition calculations lead to strong fields of typically 25 μG. If this were invalid, and assuming a field of 5 μG, then T_{syn} would be about 10 times larger. There are several possibilities to explain the discrepant ages derived from stellar colors and relativistic electrons. Radio spectra reflect the current or recent star forming activity in a few localized areas, whereas the integrated optical colors do not extract star forming regions. Or, the galaxies might undergo a bimodal star formation, where we currently observe a burst which is dominated by mass rich O stars, which follows a previous starburst which was dominated by lower mass stars. The radio-emission reflects the relativistic electrons which were injected by the very young O stars' supernovae, whereas the optical colors reflect the older starburst. Finally, the radio spectra would not indicate a starburst's age if they are not dominated by synchrotron aging but instead by free-free absorption at low frequencies. In conjunction with the optical data, the radio spectra can give quantities like the IMF, the abundances of O stars, the star formation rate and act as a guide towards a detailed picture of these galaxies' interstellar environment and their star formation history.

	Haro 15	II Zw 40	Mkn 297	Mkn 314	III Zw 102
$B-R_{25}$	0.67	0.73	0.92	0.86	0.60
$B-R_{core}$	0.47	-0.015	0.99	0.84	0.75
U-B	-0.41	-0.36	-0.45	-0.35	-0.14
b	0.006	0.005	0.001	0.004	0.02
$T_b[10^6$ yrs]	70	80	25	70	150
$T_{syn}[10^6$ yrs]	3	...	7	...	2