NAG 3-362

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AUGUST 1984

IAP 84-22

(NASA-CR-174354) INTERNATIONAL ULTRAVIOLET EXPLORER OBSERVATIONS OF AMORPHOUS HOT GALAXIES (Illinois Univ., Urbana-Champaign.) 46 p HC A03/MF A01 CSCL 03B

N85-19904

Unclas

G3/90 14242

INTERNATIONAL ULTRAVIOLET EXPLORER OBSERVATIONS OF AMORPHOUS HOT GALAXIES[1]

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ABSTRACT

Amorphous galaxies are blue, irregular-like systems which lack the spatially distinct OB stellar groups that are characteristic of most late-type, actively star forming galaxies. This difference in star forming patterns is not understood, and could be symptomatic of abnormal upper initial mass functions. In order to better understand the nature of star formation processes in these unusual galaxies, we have obtained short wavelength IUE spectra of the amorphous galaxies NGC 1705 and NGC 1800. The IUE data for NGC 1705 are of excellent quality while the low signal-to-noise NGC 1800 observation is useful only as a rough guide to the ultraviolet energy distribution. We find that NGC 1705 contains a normal mix of OB stars, which is consistent with the nearly constant recent star formation rate inferred from new optical data. NGC 1800 is likely to have similar properties, and blue galaxies with amorphous structures thus do not show evidence for anomalies in stellar mass distributions. The UV spectra of amorphous galaxies and a variety of other hot extragalactic stellar systems in fact have similar characteristics, which suggests OB stellar populations often are homogeneous in their properties.

I. INTRODUCTION

In most actively star forming galaxies, including the Milky Way and Magellanic Clouds, the birth of massive OB stars does not occur at random. Instead massive stars tend to be concentrated into spatial groups which are observed as OB stellar associations and are commonly used to trace sites of recent star formation in late-type spiral and irregular galaxies (Ambartsumian 1955; Blaauw 1964; Sharpless 1965) Exceptions to this pattern are rare in nearer galaxies, and are usually found in regions with low stellar birthrates (e.g. NGC 6822; Kinman, Green, and Mahaffey 1979). The tendency for OB stars to appear in groups or clusters is interpreted physically in terms of the collapse of spatially distinct large interstellar gas complexes (Mouschovias et al. 1974; Lada et al. 1978; Elmegreen 1982 and references therein).

This process occurs with remarkable similarity among galaxies with widely different global properties. The dominant HII complexes in spiral and Magellanic-type irregular (Im) galaxies are similar in size and luminosity (Sandage and Tammann 1974, Kennicutt 1979 a,b,c; Hunter 1982). Detailed studies of OB associations in Local Group galaxies also are suggestive of parallel developmental processes (e.g. Humphreys and Sandage 1980). The initial mass function (IMF) of massive stars in the LMC (Israel and Koorneef

1979, Dennefeld and Tammann 1980) is not notably different from that in the Galaxy (Garmany, Conti, and Chiosi 1982).

However, there is a class of blue, irregular-like galaxies which are remarkable for their lack of distinct OB stellar groups, even though several OB star-rich examples are close enough for such features to be easily resolvable. These systems are a subset of the IO or Irr II galaxies described by Holmberg (1958) and fall in the amorphous class of galaxies defined by Sandage and Brucato (1979; see also Krienke and Hodge 1974). Basically amorphous galaxies have smooth, elliptical-like optical image properties, but most non-interacting members of the class resemble the Magellanic (Im) irregulars in terms of global parameters; i.e. they have low total masses, high hydrogen contents, moderate luminosities, and blue colors (e.g. NGC 1800-Gallagher, Hunter, and Knapp 1981; hereafter GHK).

Optical spectra of amorphous irregulars reveal extensive nebular emission in combination with higher Balmer series hydrogen lines in absorption and a pronounced stellar Balmer jump. These spectral features are indicative of major optical light contributions by young-to-intermediate age stellar populations (cf. O'Connell 1970; Chromey 1973, 1974 a,b; Barbieri, Bertola, and di Tullio 1974; Sandage

1978; Andreasyan and Khachikyan 1979; Sandage and Brucato 1979; Hunter, Gallagher, and Rautenkranz 1982, hereafter HGR). Star formation has been active at least over the past 10^9 years in amorphous galaxies, and is continuing. Spatially extended optical emission lines from ionized hydrogen regions show that OB stars with masses of $> 15M_{\odot}$ are present and in some cases the inferred star formation rates are so high that the galaxies may be in star formation burst phases (cf. NGC 1569; Gallagher, Hunter, and Tutukov 1984; hereafter GHT). Yet, in spite of the presence of ionized gas and distinct HII complexes, which albeit tend to blend into one another, individual OB associations are not obviously present in amorphous systems.

Thus, the formation of OB stars in amorphous irregulars is a puzzle which deserves a closer look. In particular, a comparison of the characteristics of the massive stellar populations in amorphous systems with those of OB complexes in normal Im galaxies provides an interesting means to study star formation processes in galaxies which appear to differ primarily in their natal stellar clustering properties. For example, we might understand amorphous galaxies as resulting from a tendancy to produce many lower mass stars in diffusely distributed small groups, in preference to the normal associations which contain high mass O stars ($M > 30M_{\odot}$). In other words, the distinguishing structural properties of amorphous irregulars could be symptomatic of unusual OB star initial mass functions occurring on galactic scales. Im and related types of blue galaxies are regarded by some as prime candidates for abnormal mass distributions of young stars although this view is controversial (Gallagher and Hunter 1984). Support for variable initial mass functions is provided by the tendency for Im systems to have very blue optical colors and strong optical emission lines which do not fit comfortably into conventional models for galactic stellar populations (e.g. see Searle, Sargent, and Bagnuollo 1973; Huchra 1977, Terlevich and Melnick 1981, 1983).

In order to further explore the massive stellar populations in systems with potentially abnormal stellar content we have obtained IUE satellite ultraviolet spectra and new optical measurements of two amorphous galaxies, NGC 1705 and NGC 1800. These observations allow us to make empirical comparisons with similar data culled from the literature for normal OB star complexes in late-type galaxies. The new observations are presented in Section II and the results are discussed in Sections III and IV. Section V contains our conclusions.

II. THE OBSERVATIONS

a. Ultraviolet Data

Short wavelength, low dispersion, large aperture spectra were obtained of NGC 1800 and NGC 1705 with the International Ultraviolet Explorer Satellite on the 14^{th} and 15^{th} May 1983, respectively. In low dispersion mode, the short wavelength camera (SWP) on the IUE covers the range in wavelength 1150 - 2000Å, with a resolution of about 6Å. The large entrance aperture has dimensions 10 by 20 arcsec. Table 1 lists the two observations together with information on exposure times, continuum and background flux levels, as well as the estimated noise. The continuum-to-background ratio of 4:1 for the NGC 1705 detection is high enough to allow a detailed analysis of the spectrum. However, the corresponding ratio for the NGC 1800 detection was only 1.5:1 due to an abnormally high detector background level, which precludes a detailed analysis, but does allow the general slope of the UV spectrum to be established. The locations of the aperture on the object for the observations of NGC 1800 and NGC 1705 are shown in Figure 1.

The spatial distributions of light in the IUE extracted spectra were investigated using the computer software available at the Goddard Space Flight Center Data Reduction Center and in particular were examined for clumps within the aperture (cf. NGC 4214; Huchra et al. 1983). None were found, thus indicating that on the scale of ~ 5-10 arcsec the regions investigated are smooth in the UV. A customized extraction of the central seven and eleven scan lines of the digital spectral arrays was performed for the NGC 1800 and NGC 1705 data, respectively. The background flux level was used as the criterion for elimination of the outer scan lines on each of the two dimensional images containing the spectra.

The customized extracted data were then further analyzed at the University of Illinois using a VAX 780 computer system. The Illinois spectral analysis program of S. Kenyon, D. Hunter, R. Shaw and H. Bushouse was used to perform a "Hanning-weighted" smoothing of the data. For the low signal-to-noise NGC 1800 data an eleven point smoothing was necessary and for the NGC 1705 data a three point filter width proved sufficient. Equivalent widths of the identified absorption lines in the NGC 1705 spectrum were then measured using a straight line continuum set by eye at the boundaries of each absorption line. Plots of the customized extracted spectra, with line identifications in the case of NGC 1705, are shown in Figures 2 and 3.

At first glance, the IUE spectrum of NGC 1705 resembles that of a B star. A comparison of the rough continuum energy distribution and the relative strengths of Si IV at λ 1400 and C IV at λ 1555 with the *IUE* Spectral Atlas (Wu, *et al*. 1981) shows the strongest similarity to a B1 I star. Table 2 lists the absorption lines, identifications, and the measured equivalent widths. Prominent interstellar lines are those of Si II, C II, and Al II. Note that the 'emission' bump at λ 1470 and the N IV feature at λ1720, which are indicative of Wolf-Rayet stars are weak or absent in NGC 1705.

b. New Optical Data

In January 1983 JSG and DAH obtained various optical photometry and long slit spectra of NGC 1705 and NGC 1800 at Cerro Tololo InterAmerican Observatory (CTIO). The photometric data consist of integrations through UBVR and Hα filters using an S20 photometer on the CTIO 0.9m and 1.5m telescopes. The circular aperture diameters were 132" and 14" for NGC 1705, and 57" for NGC 1800. The Hα filter was 103Å wide centered on 6586Å, so the [NII] λλ6548,84 lines are included. Reductions were made to the Johnson UBV system using both Landolt (1973) and Graham (1982) standard stars. The observations are presented below in Table 3.

The long slit spectra were taken with the "big UV" SIT vidicon on the RC Spectrograph attached to the CTIO 4m telescope. A 316 lmm^{-1} grating blazed at 4400Å was used in first order to cover 3300-7100Å. The contamination by the second order of wavelengths redder than about 6600Å was determined by observing standard stars with a GG 495 filter and was found to be small compared to other problems in the data. The slit was of width 375 μ m (2.5") for a wavelength resolution of about 10Å; the slit length was 3' for a spatial resolution of 1.2" per pixel. Each night's observations included darks, He/Ar and Hg comparison spectra, projector flats using a lighted white screen on the dome, twilight sky frames, and generally three standard stars. Data were reduced with the Kitt Peak National Observatory image processing system. Standard procedures were followed which included a sequence of subtracting darks, dividing by the flat field and slit profile, using the arc spectra to correct for curvature along the slit, using a star to correct for curvature along the dispersion, subtracting sky using blank regions along the slit, fluxing, and multiplying by a mean atmospheric extinction correction (determined for KPNO).

The limited dynamical range, as well as the general instability and high noise, in our data from the big UV SIT detector present serious problems in NGC 1705, which has a steep radial gradient in surface brightness and strong optical emission lines. In particular it proved difficult to obtain unsaturated observations of the central stellar continuum in NGC 1705. A sample spectrum, which has rather typical characteristics for a blue Im galaxy (HGR), is illustrated in Figure 4. For NGC 1800 northern hemisphere spectrophotometry obtained with a 23 arcsec aperture with the KPNO 0.9m telescope (HGR) and Hα imaging with the video camera on the KPNO 2.1m telescope (see Hunter 1982) are also available.

III. PROPERTIES OF THE ULTRAVIOLET SPECTRA

a. Interstellar Absorption Features in NGC 1705

The strong interstellar lines seen in NGC 1705 reflect absorption due to gas within NGC 1705 and in our Galaxy (our spectral resolution is insufficient to resolve these two components for the 640 km s^{-1} redshift velocity of NGC 1705; Lauberts 1982). Since NGC 1705 lies comparatively near the Large Magellanic Cloud (separation of ~ 20°), we have used the data presented by Savage and de Boer (1981) to roughly estimate the Galactic interstellar equivalent widths. Furthermore the actual Galactic and NGC 1705 interstellar lines will be sharp and thus separated in wavelength by the redshift. The blending caused by the instrument will thus produce a feature which has an equivalent width that is approximately the sum of the Galactic plus intrinsic interstellar components, and corrections therefore are straightforward.

Results are presented in Table 2, where we also have used the Savage and de Boer LMC data as a guide to interstellar line strengths in hot galaxies. Note that our CTIO SIT spectra suggest that, like the LMC, NGC

1705 has lower than solar gas metallicity but is not extremely metal deficient. This enables us to classify the nature of the observed absorption lines, most of which are interstellar in origin. The only potentially anomalous result is the great strength of Al II λ 1677, which also is seen to be quite pronounced in H II regions such as NGC 604 (Massey and Hutchings 1983; see also Fitzpatrick and Savage 1983). In any case we can be assured that light from hot stars in NGC 1705, as in other gas-rich extragalactic systems, is not, on the average, reaching us directly, but rather has interacted with interstellar matter which produces absorption lines and also will modify the emergent UV spectral energy distribution. We therefore must rely primarily on stellar spectral features to diagnose the mix of stars responsible for the UV luminosity of NGC 1705. This interpretive difficulty, of course, will apply to hot, gas-rich galaxies in general.

b. Stellar Absorption Features in NGC 1705

Both the C IV and Si IV blends originate primarily from stellar photospheres and are approximately equal in strength. This fact immediately excludes a dominant UV luminosity contribution by very high mass (> 30-40 $M_{\odot}$) stars, as does the absence of strong P Cygni profiles. For example, the luminous stellar clumps observed in M33 H II regions by Massey and Hutchings (1983) are characterized by obviously stronger C IV than Si IV absorptions, and by the presence of at least moderate C IV emission. In the hot Irr galaxies NGC 4214 and NGC 4670, the C IV absorption line is only slightly deeper than that of Si IV, thus the situation in these systems is more closely comparable to that in NGC 1705, despite pronounced morphological differences between the galaxies themselves (Huchra et al. 1983).

NGC 1705, however, has UV colors that are as blue or bluer than these objects which again illustrates the difficulties in using UV colors to determine stellar content in gas-rich galaxies. An additional complication is introduced by the apparent sensitivity of the Si IV and C IV features to abundances as well as to stellar temperature. Although we do not have precise abundance determinations for NGC 1705, a rough application of Pagel et al's. (1979) method suggests an oxygen abundance relative to hydrogen that is near the LMC value. We have therefore used Hutchings (1982) IUE observations of LMC stars as a guide to appropriate C IV and Si IV stellar equivalent widths as a function of spectral type and thus of stellar temperature.

The IUE spectrum (and also optical emission lines) thus rule out any extreme deficiencies of OB stars in NGC 1705. The strengths of C IV and Si IV are closely matched to those expected for a B0 or B1 star in an intermediate metallicity level Im galaxy, which corresponds to main sequence stars with masses of ~ 20

M_O. This observation provides a lower bound to the maximum masses of stars present in NGC 1705 since: 1) Supergiants will also contribute to the spectrum, and stars with early BI spectral classes can originate from stars with initial masses of $\gtrsim$ 20 M_O. 2) In agreement with the first point, models based on normal initial mass functions, predict that stars with M ~ 20 M_O will be the main sources of flux from composite stellar systems at 1500Å even though considerably higher mass stars are in fact present in normal numbers (Israel and Koorneef 1979). If there is any major abnormality in the upper initial mass function in NGC 1705, then it must occur only for the most massive stars and is unlikely to be solely responsible for the optical appearance of this galaxy (see below).

c. Spectral Energy Distributions: Stars and Dust

Interstellar dust has profound effects on the UV spectral energy distributions of galaxies. For example, interstellar extinction curves for the LMC tend to rise nearly linearly over the wavelength region of interest here, with $E(\lambda-V)/E(B-V)$ increasing from 1 to 6 magnitudes depending on the state of the interstellar medium (ISM) through which the light is passing (nebular vs. normal ISM; Fitzpatrick and Savage 1984).

The situation is further confused by observations of nearby galaxies which show major variations in the

UV extinction laws. For example, neither of the Magellanic Clouds have the pronounced 2200 Å 'bump' in the extinction curve which is characteristic of normal extinction in the Milky Way (see Savage and Mathis 1979; Koorneef and Code 1981; Fitzpatrick and Savage 1983). There are also indications that M33 (Massey and Hutchings 1983) and other Im galaxies (Lequeux et al. 1981) do not follow the Galactic extinction laws. The physical causes for these differences are not well understood. Thus for the present there remains a fundamental uncertainty in the interpretation of UV spectra, but light emerging from a galaxy in any case will be dimmed by the absorption component of interstellar extinction which results in a net loss in radiated UV energy.

In addition starlight will be scattered by dust, especially in the comparatively dense H II regions, and the intensity of such scattered light can in principle equal or exceed the light directly received from the embedded stars. The spectrum of the scattered component will furthermore depend on details of the particular situation and thus is not easily predicted (c.f. Bohlin et al. 1980; 1982; Perinotto and Patriarchi 1980; Stecher et al. 1982). As a result of these processes, the UV flux distributions from gaseous galaxies will depend in complex and at present inseparable ways on both stellar and ISM properties.

Experience, however, suggests that the UV spectra of hot galaxies are usually reddened versions of the intrinsic composite stellar spectral energy distributions (e.g. see Israel and Koorneef 1979; Morgan, Nandy, and Carnochan 1979, Maucherat-Joubert, Lequeux, and Rocca-Volmerange 1980; Page and Carruthers 1981); so the situation evidently is not completely arbitrary.

Optical measurements of emission line Balmer decrements in amorphous galaxies show that these systems are relatively free of dust (GHK, HGR, Hunter 1982). Furthermore, stellar population synthesis models based on optical spectra or colors predict the flux at 1400Å to within a factor of three for NGC 1800 and two for NGC 1705. The models always overestimate the UV flux, and this suggests an upper limit on the overall average extinction of $E(B-V) \sim 0.2$.

Given that properties of both stars and interstellar matter can affect UV spectra, it is then all the more remarkable that UV colors of hot galaxies are in fact observed to be quite similar. UV data on galaxies and regions of galaxies with large young stellar populations are collected from <u>IUE</u> and other studies in Table 4 and plotted on a color-color diagram in Figure 5, where we see that even the metal-rich star-burst M 83 spiral galaxy nucleus does not stand out. One possibility is that congruence in the structure and evolution of stars and gas in large OB star forming regions produce relatively homogeneous UV energy distributions.

Of course, the UV spectra are not identical, and there are some puzzles. For instance, NGC 1705 has extremely blue UV colors, and yet also has a normal compliment of interstellar absorption lines implying that its OB stars are embedded in gas (and presumably dust). It is also clear that in NGC 1705 the stellar population mix is not overly biased toward very massive, unusually hot stars. Perhaps this is a case in which scattering by dust is relatively important, or alternatively variations in the forms of interstellar scattering and absorption may lead to unusual UV colors.

IV. STRUCTURAL AND EVOLUTIONARY CHARACTERISTICS

a. Star Formation Rates

Following the approach developed by GHT we can place the star formation histories of the two program galaxies on a systematic basis. This exercise allows us to check for relationships between UV spectra and evolutionary properties. Briefly, three star formation rate indicators can be defined as probes of different time scales: α_m is a normalized birth rate derived from the total mass of stars and therefore is sensitive to the average star formation rate integrated over the galaxy's lifetime ($\sim 10^{10}$ yr), α_L is based on blue luminosity and estimates stellar production over ~ 10^9 yr in hot galaxies, and the current stellar creation rate is given by α_c, which is proportional to the number of Lyman continuum photons and thus to the number of OB stars. The normalization of the α's is given in terms of a Salpeter (1955) form for the initial mass function (IMF), i.e. $dN = \alpha M^{-2.35} dM$. The total birthrate then depends on the choice of lower mass cutoff, and is 16.6α for a lower cutoff of 0.1 $M_\odot$, or equivalently $\dot{M} = 6.41\alpha\ M_\odot\ yr^{-1}$ for this choice of IMF.

Galaxy-wide star formation rate estimators are included as part of Table 3. The α_L are from our CTIO large-aperture photometry and data in GHK. Hα emission fluxes were converted to the number of Lyman continuum photons through $N_c = 8.78\ 10^{61}\ F_c(H\alpha)\ D^2(Mpc)$, and thus we are ignoring internal reddening which leads to a conservative estimate for α_c. For NGC 1800 a total Hα flux was found from calibrated Kitt Peak video camera images as described by GHT. NGC 1705 was measured through an Hα interference filter with single channel photometers on the CTIO 0.9m and 1.5m telescopes, and these data were placed on an absolute flux scale using NGC 1800 and NGC 5253 as calibrators. The NGC 1705 Hα flux is preliminary and a full discussion of CTIO observations of hot galaxies will be presented elsewhere. Since a total mass has been estimated for NGC 1800 by GHK, we can in this case also calculate α_m; no HI measurement or dynamical mass is available for NGC 1705.

As in other Irr-type galaxies, NGC 1800 has $\alpha_L \sim \alpha_C < \alpha_m$. We therefore deduce following GHT and in agreement with GHK that the astration rate has been nearly constant over the past several billion years, although it may have recently declined slightly as compared with the lifetime average. NGC 1705 presents a different pattern; here $\alpha_C > \alpha_L$ which suggests the galaxy is in a mild star formation burst phase. The small-aperture optical photometry, however, suggests that the region observed with the *IUE* is in a *local* post-burst phase with weaker emission than the galactic average. This picture is supported by the long slit CTIO SIT spectra, which detect a major emission region that contributes heavily to the total Hα flux but is well off of the bright stellar core (see Figure 6).

b. Evolutionary Status of H II Regions

An additional diagnostic of conditions within areas of galaxies covered by the *IUE* aperture is provided by the ratio of Hβ flux to the UV galactic flux at 1400Å. As described by Huchra *et al.* (1983), this ratio is sensitive to the presence of very massive stars ($M > 30\ M_{\odot}$; these normally provide most of the H-ionizing flux) and to the developmental phase of the individual H II-OB stellar complexes. In most instances H II region evolutionary effects probably are dominant. For example, in young HII complexes optical emission may be detected from the Strömgren spheres of stars which are themselves seen only as infrared sources (e.g. Habing and Israel 1979). We would thus have a UV color ratio of $R(H\beta - 1400) \equiv F(H\beta)/F(1400x1A) \rightarrow \infty$ in young H II complexes. At the other extreme, old star forming complexes can expel cool gas from their surroundings, and even though hot stars may be present, the Hβ flux will be reduced and R(Hβ-1400) will decline toward zero (see Tenorio-Tagle 1984). Effects of this type generaly will <u>not</u> correlate with UV continuum energy distributions found from <u>IUE</u> spectra, and indeed in Figure 7 (see Table 5) we see that such correlations are absent[6]. Furthermore, the very high values of R(Hβ-1400) found in some giant

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[6]The point here is that UV extinction is likely to be so severe that it produces a picket fence effect, i.e. the UV flux from large regions in galaxies will be dominated by the least extincted stars. As a result of this process and the importance of scattering of UV light discussed earlier, the degree of reddening of the UV spectral energy distribution and amount of dimming due to dust probably are, at best, loosely correlated when one examines large areas in galaxies.

H II complexes would, if interpreted solely in terms of stellar content, require extraordinary departures from normal initial mass functions (e.g. ultraluminous, super massive stars) whose routine existence we doubt (see Huchra et al. 1983, Gallagher and Hunter 1983, 1984). The low R(Hβ-1400) in the NGC 1705 core then suggests this region contains relatively few young H II complexes as compared with other hot galaxies.

c. Discussion

All of the available data then are consistent with a model for the center of NGC 1705 in which a major star forming event has evolved to the point where the hot stars have largely emerged from their natal gas. This phenomenon is not unique, but is seen in a variety of normal, actively star forming galaxies. For example, the central OB star cloud in Constellation III in the LMC is located in a gas hole (Westerlund and Mathewson 1966; Meaburn 1980) as is the giant OB star complex NGC 206 in the spiral galaxy M31 (Brinks 1982). The unusual features of the event in NGC 1705 are its smooth high surface brightness, large luminosity, and minimal numbers of surrounding features (e.g. other smaller OB star complexes) which produce little optically resolvable structure. That a small galaxy should support few active star forming centers is not surprising, but that the one should be a dense supergiant OB complex is remarkable.

In this regard NGC 1705 resembles an evolved version of moderate luminosity extragalactic H II regions of the II Zw 40 type (Baldwin et al. 1982). We do not know, however, whether the core region in NGC 1705 actually consists of a single coherent OB stellar group or of many smaller OB clusters that overlap along the line of sight. Nevertheless, the IUE spectrum shows that the massive component of the stellar population is typical of large star-formation events found in other galaxies (see also Lequeux et al. 1981).

NGC 1800 definitely contains more than a single major star forming center, as can be seen from the multiple H II complexes detected in echelle spectra obtained by Hunter (1982). These individually appear to be small, but evidently spatially overlap to give rise to the amorphous appearance of NGC 1800 (Sandage and Brucato 1979; GHK). Since our IUE data are of poorer quality for NGC 1800, we have less information on the specifics of the hot stellar population mix than in NGC 1705, but again there are no indications of major stellar population anomalies associated with the unusually smooth spatial pattern of star formation.

V. SUMMARY

NGC 1705 at 13 Mpc and NGC 1800 at 16 Mpc (H_o = 50 km s^{-1} Mpc^{-1}) should be resolvable into OB star clusters and associations such as are found in the Magellanic-type irregular galaxies; yet individual OB star groups are not readily apparent in these amorphous systems. The IUE spectra and optical data that we have presented, nevertheless, clearly show that amorphous galaxies can and do form massive stars in a near normal fashion. Furthermore, comparisons with the UV spectra and colors of intermediate metallicity Im systems (eg. NGC 4214, 4670) and giant H II regions in spirals (eg. NGC 604, 5471) as well as the metal-rich M83 nucleus (Boblin et al. 1983) have shown the remarkable similarities of 1500 Å region spectra from hot stellar systems.

In spite of the absence of distinct young stellar spatial groupings, we therefore conclude that the hot stellar populations in amorphous galaxies are typical. Why OB star clumps are not apparent and what this might be telling us about star formation processes in amorphous irregular galaxies still is not understood. Thus the amorphous galaxies are particularly interesting targets for future high spatial resolution observations.

From optical data we have found that NGC 1800, like most other irregulars, has been producing stars at a roughly constant rate over its lifetime. NGC 1705, however, may be experiencing an over-all mild enhancement of its star formation rate although the high surface brightness center itself may be in a post-burst phase. Our data show that NGC 1705's center is bluer in the UV than that of NGC 1800 or most other late-type systems, which may be a reflection of the evolved state of this system. But in either case, there are no signs of evolutionary anomalies or peculiarities in the populations of massive OB stars which might provide a single explanation for the phenomenon of amorphous structures in a small minority of Im-like galaxies.

We have also noted that hot extragalactic stellar systems have qualitatively similar spectra in the IUE short wavelength region. Similarities in spectral properties of physically diverse stellar systems are not uncommon. For example, optical spectra of older stellar populations are well known to present interpretive problems due to insensitivity of the spectra to the mixture of stellar ages and metallicities (see O'Connell 1982). We are seeing hints that this type of problem may also arise in analyzing the UV spectra of actively star forming nearby galaxies observed from space observatories and of distant, high redshift galaxies observed at traditional optical wavelengths.

We wish to thank the University of Illinois Vax Imaging Center for use of their facilities and to again acknowledge support of the National Aeronautics and Space Administration through grant NAG 5-362.

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Table 1

IUE Observations

Spectrum number	Object	Exposure Time	Continuum[a] Level	Background[a] Level	Estimated[a] Noise
SWP #19992	NGC 1705	240 min	220 DN	58 DN	15 DN
SWP #19983	NGC 1800	350 min	200 DN at short λ, 180 DN at long λ	165 DN	20 DN

[a]The continuum, background, and noise levels are given in IUE Data Numbers (DN).

Table 2

Absorption Lines in the Ultraviolet Spectrum of NGC 1705

λ_{OBS}(Å)	I.D.	W_λ(total)(Å)	W_λ(Gal)[a](Å)	W_λ(1705)(Å)	Origin
1178	CIII	1.30	b	--	stellar
1264	SiII	2.94	1.37	1.57	IS
1308	OI,SiII,SiIII	3.12	1.34	1.78	IS
1339	CII,OIV	4.22	1.65	2.57	both
1396-1409	SiIV,OIV	3.43	0.38	3.05	stellar
1531	SiII	0.75	0.78	0.03	
1555	CIV	3.84	0.62	3.22	stellar
1571-1576	?	1.44	c	--	
1677	AlII	3.47	1.05	2.42	IS

[a] Estimates from Savage and de Boer (1981).

[b] C III was not within spectral range presented by Savage and de Boer.

[c] No absorption feature listed.

TABLE 3

PHOTOMETRIC PROPERTIES OF NGC 1705 AND NGC 1800

	NGC 1705	NGC 1800
B_T^o	12.6[a]	12.9[b]
$(U-B)_o$	-0.70[c]	-0.22[c]
$(B-V)_o$	0.25[c]	0.38[c]
$(V-R)_o$	0.21[c]	0.47[c]
$(R-I)_o$	0.30[c]	-
$F_T(H\alpha)$ (erg cm^{-2} s^{-1})	2.0×10^{-12}[d]	6.2×10^{-13}
D (Mpc)	8.7	12.0
L_B/L_o	5.4×10^8	7.8×10^8
N_c (s^{-1})	1.3×10^{52}	7.8×10^{51}
α_c	0.033	0.020
α_L	0.016	0.023

[a]Colors and B_T for NGC 1705 from CTIO photometry with E(B-V) = 0.03.

[b]Colors and B_T for NGC 1800 from data in GHK; E(B-V) = 0.05.

[c]Estimated UBVRI colors from small aperture photometry for region observed with IUE.

[d]Hα fluxes from CTIO photometry; integrated over entire galaxy.

Table 4

Color Data for Hot Galaxies

Obj	4*E(B-V)	C(1550-1910)[a]	Source[b]	$(B-V)_o$	Source[c]
M82	0.13	-0.24	1	0.84	8
N 4449	0.0	-0.43±0.3	1	0.41	8
N 4449	0.0	-0.23±.02	2	0.37	9
N 604 (N598)	0.18	-0.58	3	-0.30	10
N2363(N2366)	0.17	-0.27	4	-0.30	11
N 4214	0.0	-0.40	5	0.33	5
N 4670	0.02	-0.20	5	0.36	5
N5471(N5457)	0.0	-0.58	3	-	-
N 1800	0.2	-0.6:	6	0.38	12
N 1705	0.18	-0.51	6	0.24	6
N5461(N5457)	0.0	-0.44	4	0.18	13
M83 nucleus	0.05	-0.36	7	0.44	14

[a]Extinction corrections for C(1550-1910) based on Savage and Mathis (1979) standard extinction curve. E(B-V) from Burstein and Heiles (1984).

[b]Source for UV colors: 1 = Code and Welch 1982; 2 = Coleman, Wu and Weedman, 1980; 3 = Rosa 1980; 4 = Lequeux *et al*. 1981; 5 = Huchra *et al*. 1983; 6 = this paper; 7 = Bohlin *et al*. 1983.

[c]Sources for B-V color of region observed in UV. Additional references: 8 = de Vaucouleurs, de Vaucouleurs, and Corwin 1976; 9 = de Vaucouleurs 1961; 10 = D. A. Hunter, unpublished; 11 = HGR; 12 = GHK; 13 = Wray and de Vaucouleurs 1980; 14 = Talbot, Jensen and Dufour 1979.

Table 5

Additional Color Data for Hot Galaxies[a]

Obj	$C(1550-1910)_o$	$F(H\beta)/F(1400*1A)$[b]	$C(H\beta-1400)_o$
N604	-0.58	2.5	-0.85
N2363	-0.27	35	-3.67
N4214	-0.40	3.8	-1.45
N4670	-0.20	7	-2.09
N5471	-0.58	10	-2.50
N1800	-0.6:	10	-2.70
N1705	-0.51	7.8	-2.03

[a]Extinction corrections from Savage and Mathis (1979), $E(H\beta-1400) = -4.39 * (E(B-V))$.

[b]H_β fluxes from Huchra et al. (1983) except NGC 1705 and NGC 1800, which are from the observations described in this paper. All colors are approximately scaled to the IUE aperture.

FIGURE CAPTIONS

Fig. 1. The orientation of the IUE aperture is shown on images of the two galaxies. That of NGC 1800 is a B image taken with the KPNO video camera on the 2.1 m telescope. Each pixel is 0.55". The 10" x 20" aperture of IUE is oriented at a p.a. of 51°. The image of NGC 1705 is an enlargement from the ESO/SERC Blue Southern Sky Survey (plate #655), and the aperture p.a. is 43°.

Fig. 2. The IUE spectrum of NGC 1800. The features at approximately λ1180 Å and λ1780 Å are reseaux; no absorption features are definitely seen due to the low signal-to-noise ratio in the spectrum.

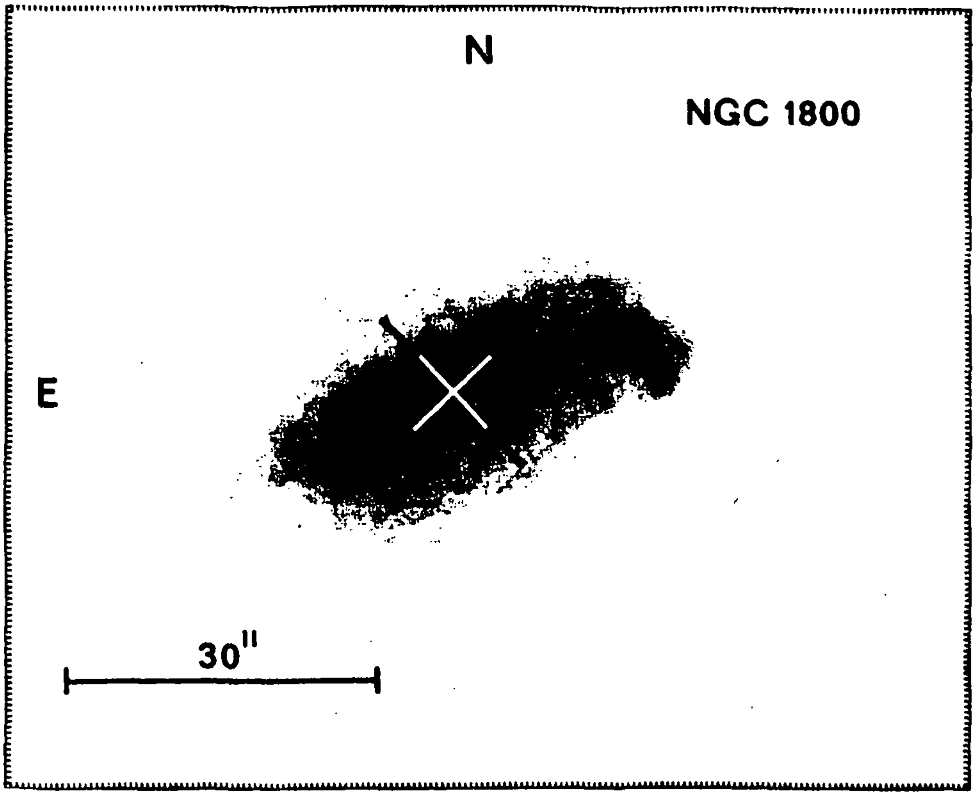
Fig. 3. The IUE spectrum of NGC 1705. Major stellar and interstellar (identified below the spectrum) absorption lines are marked.

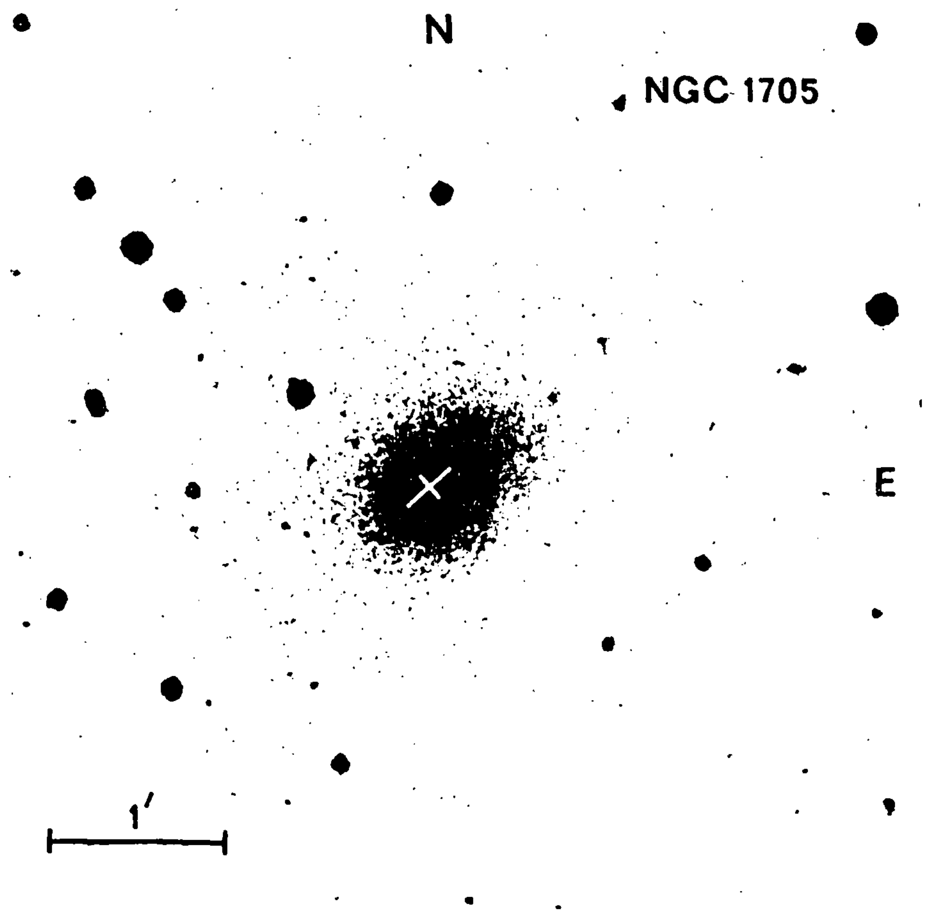
Fig. 4. A CTIO SIT spectrum of NGC 1705. Integration time was three minutes, and the spectrum is an average over ~ 20" of the galaxy. The emission line characteristics are typical for an irregular galaxy of moderate luminosity (see HGR).

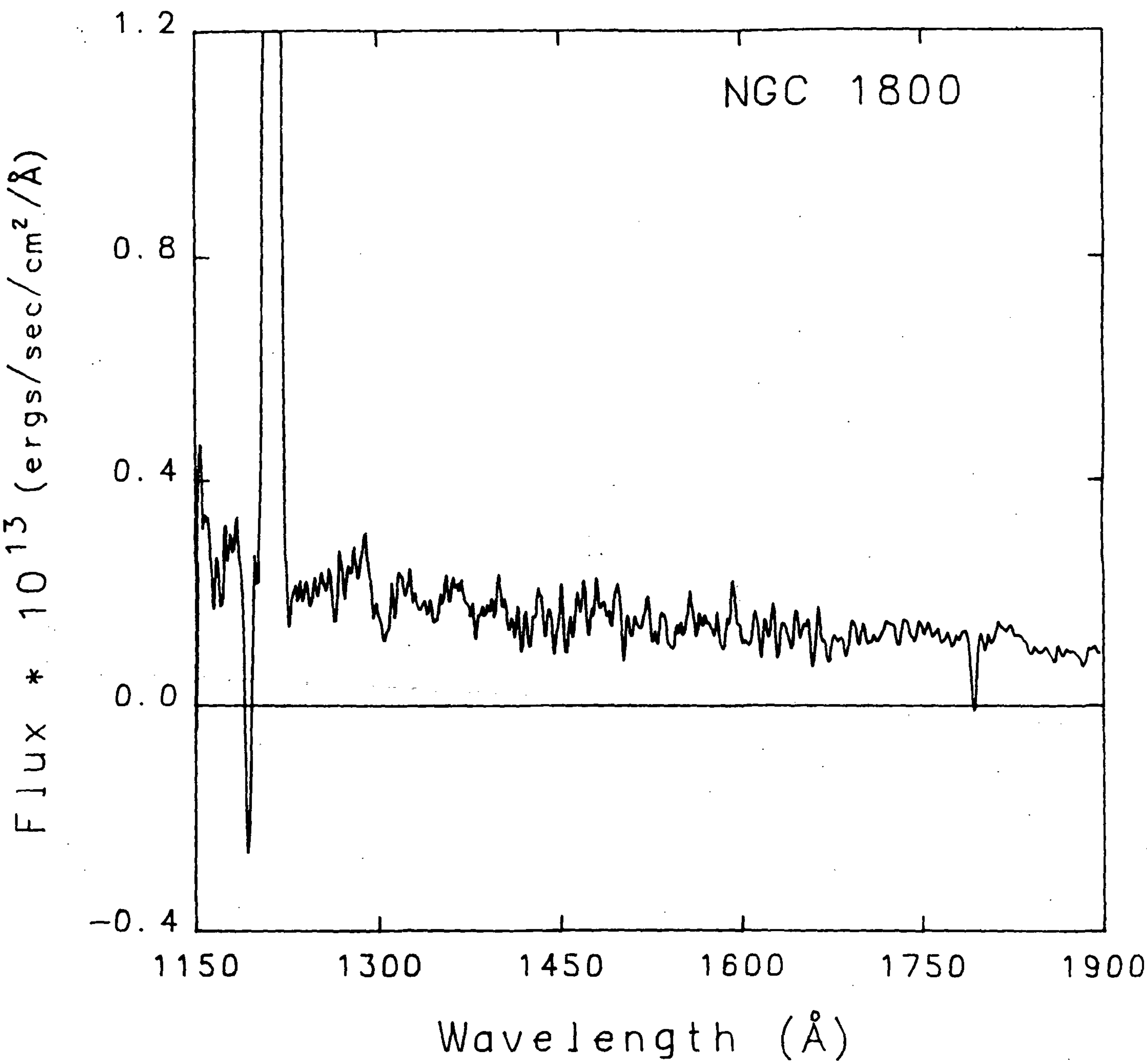
Fig. 5. Ultraviolet color C(1550-1910) vs. $(B-V)_o$ for various galaxies and regions of galaxies with large young stellar populations. See Table 4 for references.

Fig. 6. This plot shows the spatial intensity distributions of the [O III] λ 5007 nebular emission line and optical stellar continuum in NGC 1705. Clearly the ionized gas extends over a larger region than the bright stars. These data are from a CTIO long slit SIT spectrum taken with the 4m telescope with the spectrograph slit oriented a p.a. of 37°.

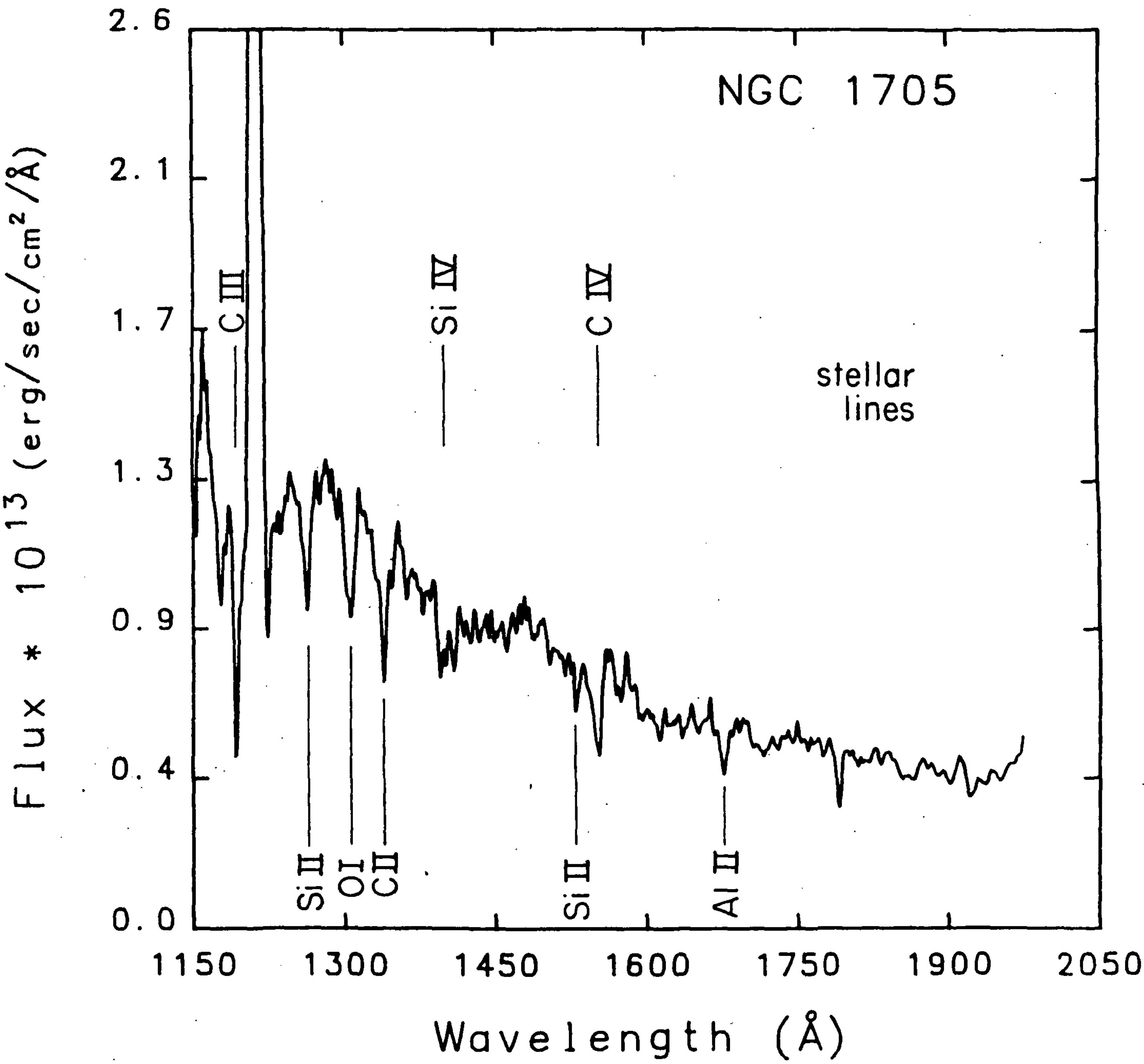
Fig. 7. A color index based on the ratio of the ionizing flux as deduced from the Hβ emission line flux to the continuum UV flux at λ1400 Å is plotted versus UV color index. Idealized position for hot stars are shown by assuming no reddening and that the stars are surrounded by radiation bounded nebulae. This color-color plot, although sensitive to reddening, provides information on the relative numbers of very massive stars.

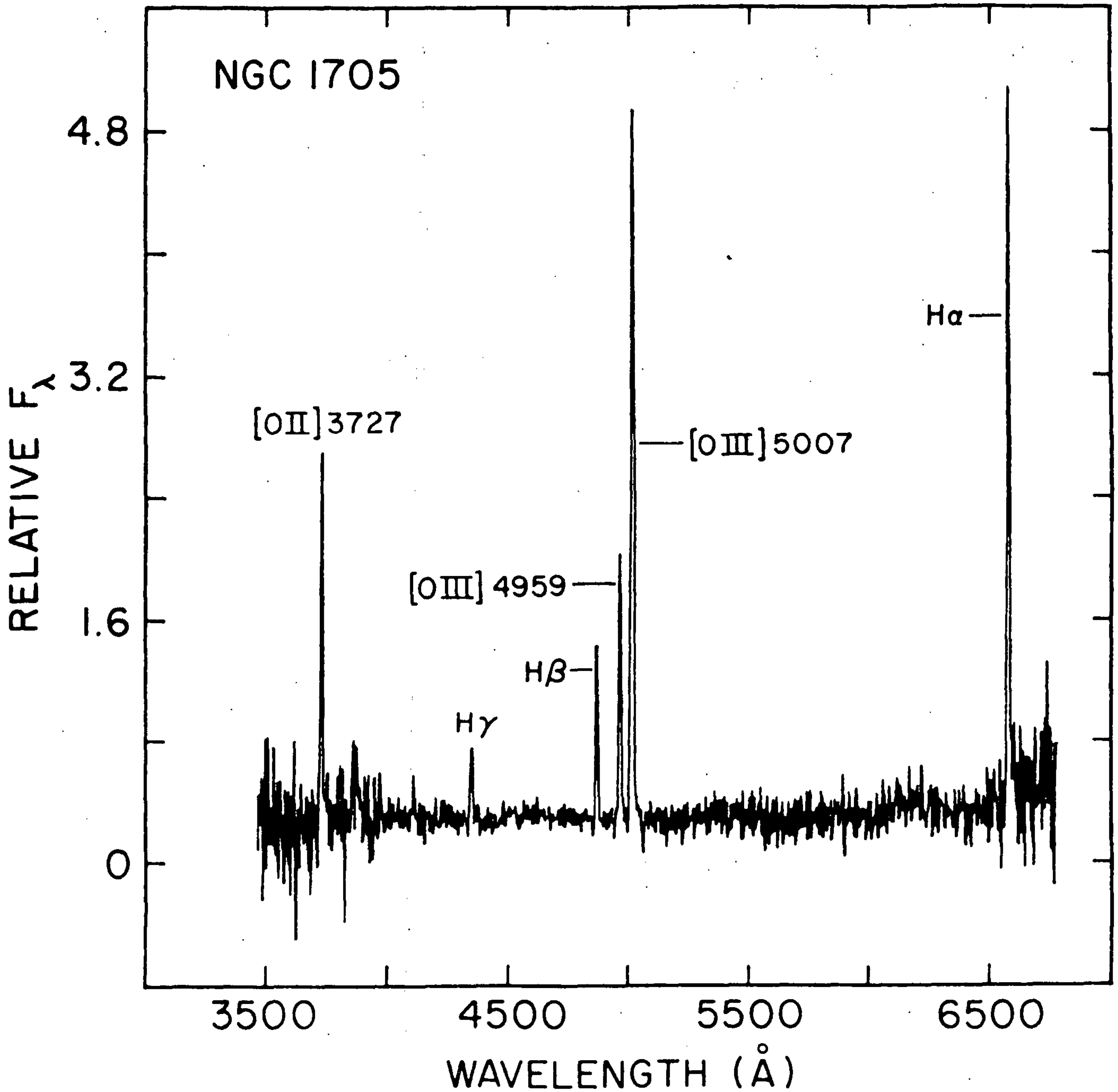

N
NGC 1800
E
30''


N
NGC 1705
E
1'

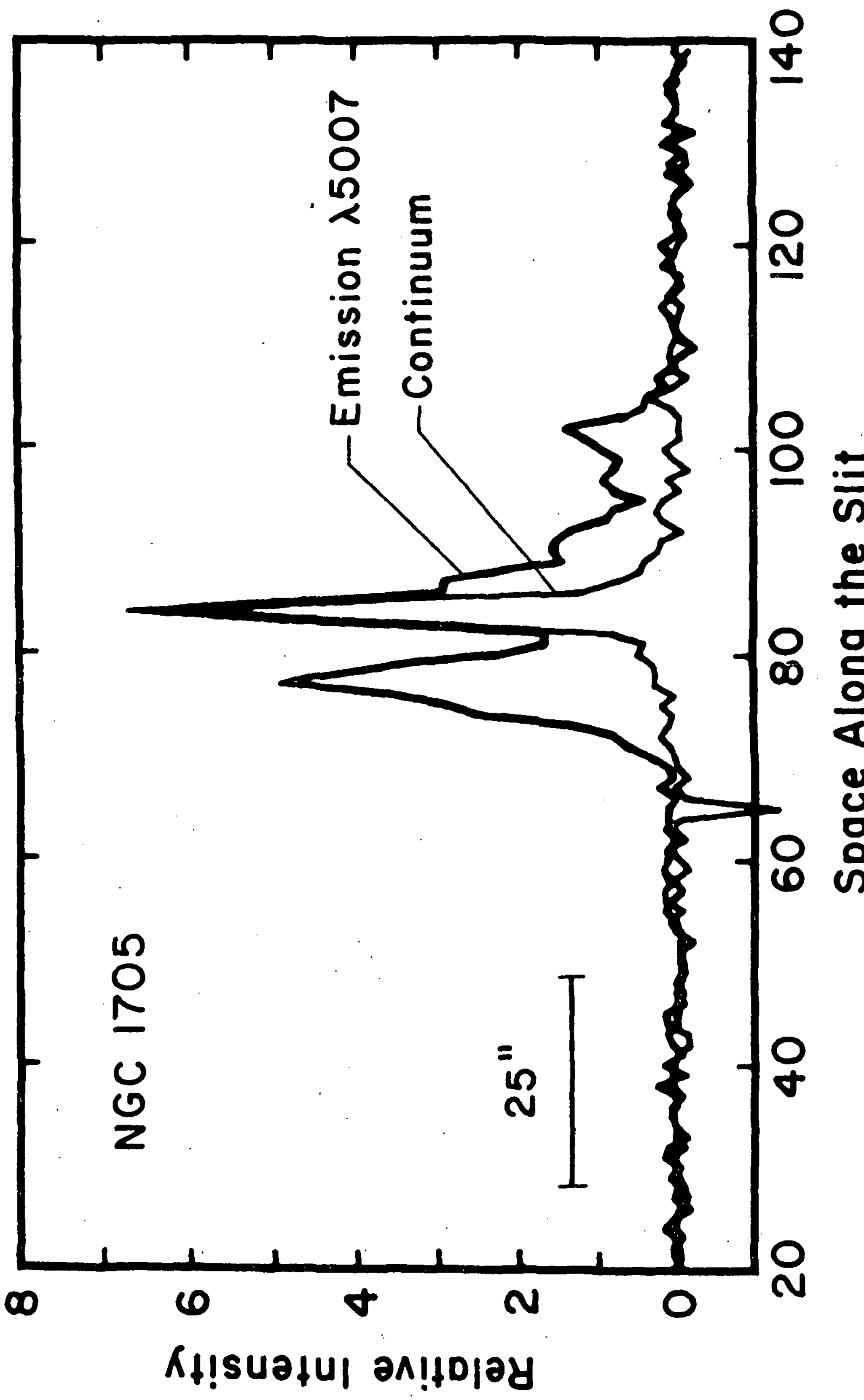


Lamb et al Fig. 2

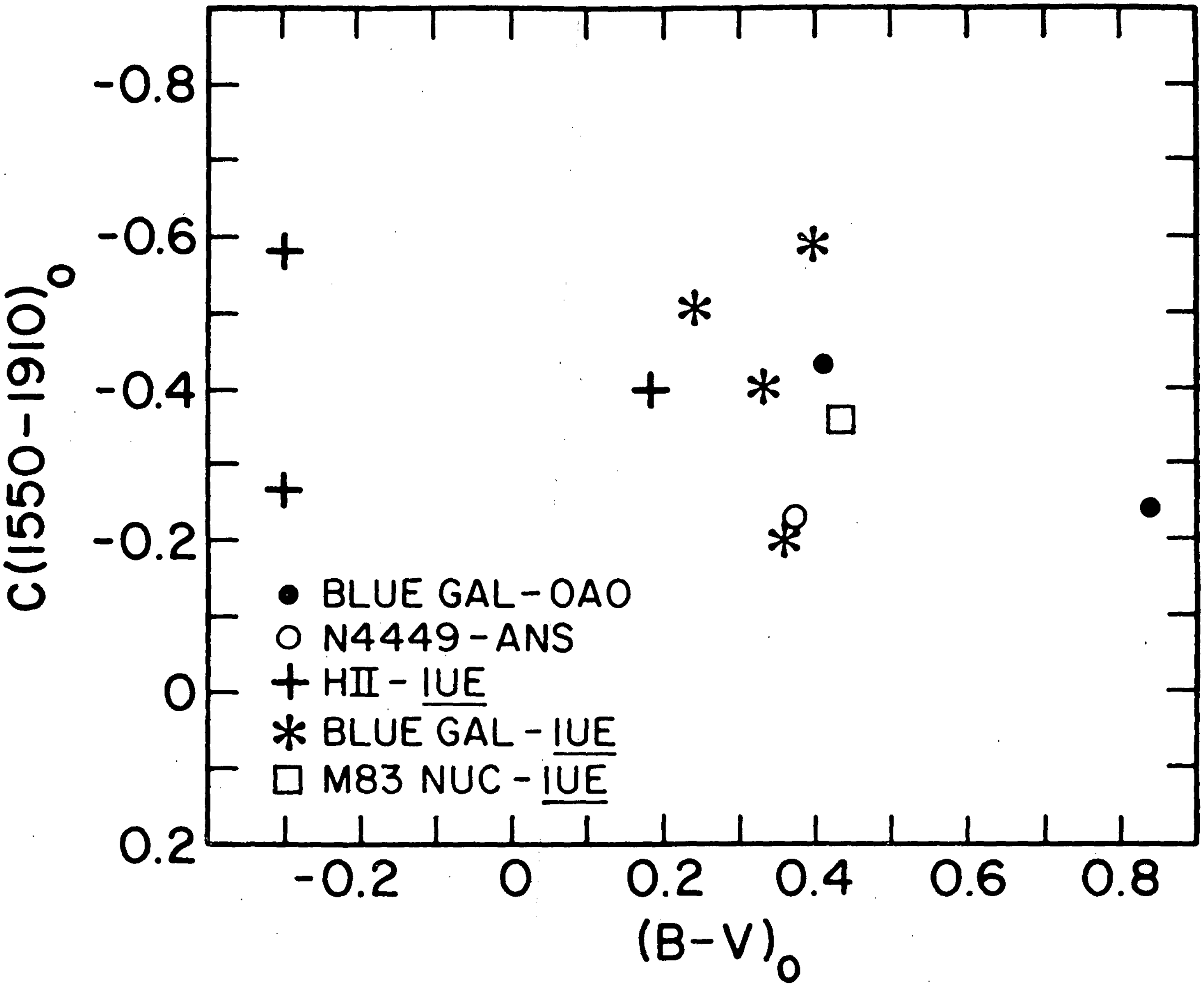

NGC 1705
Flux * 10^{13} (erg/sec/cm^2/Å)
Wavelength (Å)
C III
Si IV
C IV
stellar lines
Si II
O I
C II
Si II
Al II
2.6
2.1
1.7
1.3
0.9
0.4
0.0
1150
1300
1450
1600
1750
1900
2050



Lamb et al Fig 4

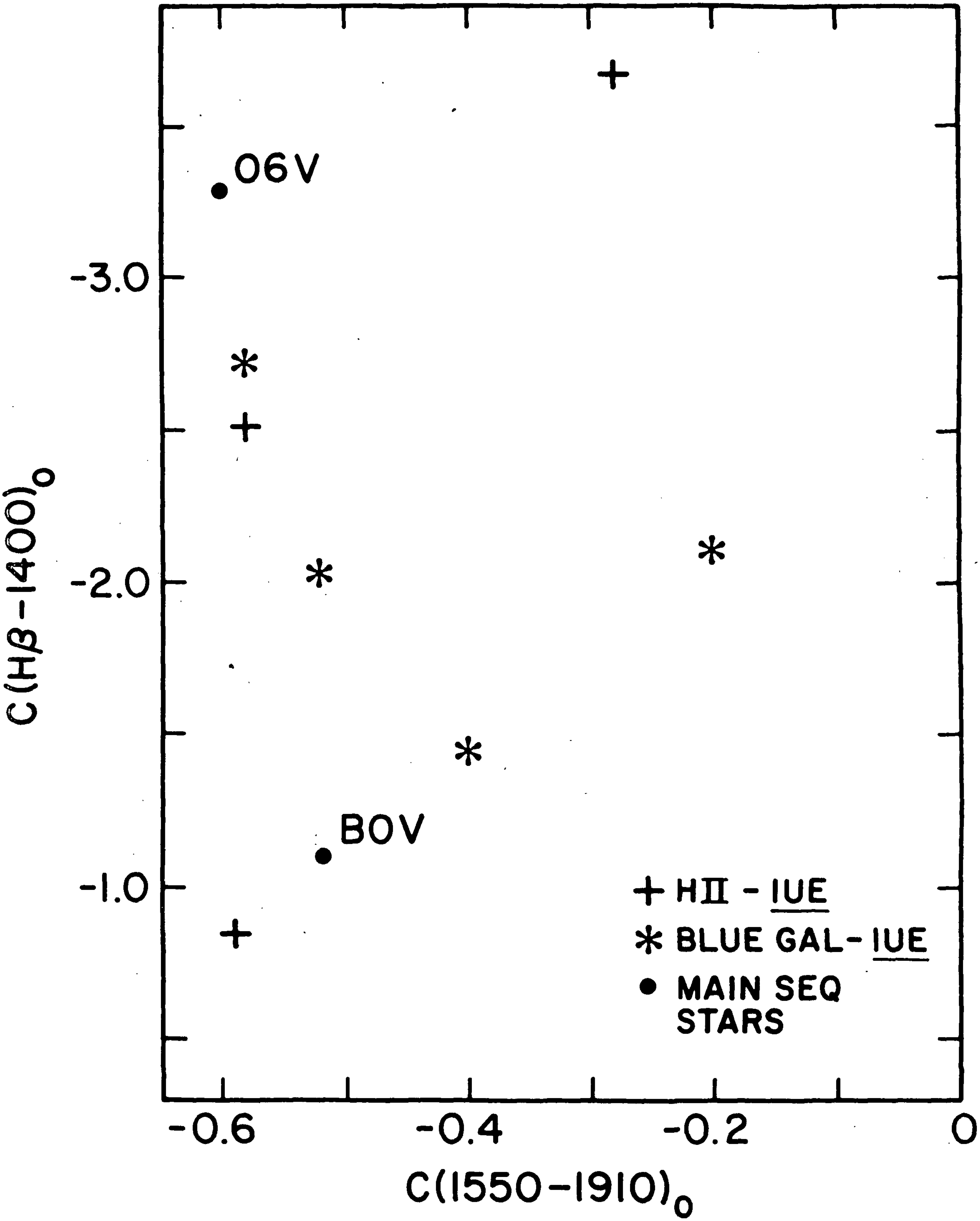


Lamb et al. Fig. 5



-0.8
-0.6
-0.4
-0.2
0
0.2
C(1550-1910)$_0$
-0.2
0
0.2
0.4
0.6
0.8
(B-V)$_0$
● BLUE GAL - OAO
○ N4449 - ANS
+ HII - IUE
✱ BLUE GAL - IUE
□ M83 NUC - IUE

et al. Fig. 6



O6V
BOV
-3.0
-2.0
-1.0
-0.6
-0.4
-0.2
0
C(Hβ-1400)o
C(1550-1910)o
HII - IUE
BLUE GAL- IUE
MAIN SEQ STARS

Fig 7

illinois astronomy * illinois astronomy
illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy * illinois astronomy