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NEAR IR SPECTROSCOPY AS A STARBURST TRACER IN ACTIVE GALAXIES [1]

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RESUMEN

Los brotes viejos de formación estelar pueden ser trazados con supergigantes rojas y hemos obtenido espectro IR de galaxias activas y con brotes. Encontramos que el comunmente usado índice espectro/fotométrico CC no es confiable para distinguir supergigantes rojas (brotes) de gigantes metálicas rojas (población vieja). Un cantidad más adecuada es el cociente luz a masa en 1.6 μm, L(H)/M, derivado de la luminosidad en la banda *H* y de la dispersión de velocidades estelares. Mientras algunas Seyfert 2 tienen cocientes L(H)/M típicos de brotes, todas las Seyfert 1 tienen cocientes similares a elípticas y espirales normales

ABSTRACT

Old, exhausting starburst events in active galaxies can be traced by red supergiants. We have obtained high quality IR spectra of normal, starburst and active galaxies and find that the commonly used CO spectroscopic/photometric index does not provide a reliable diagnostic for distiguishing red supergiants (i.e. starbursts) from metallic red giants (i.e., old stellar systems). A more sensitive quantity is the light-to-mass ratio at 1.6 μm, L(H)/M, as inferred from the observed *H* band stellar luminosities and velocity dispersions of the stellar absorption features. While some of the type 2 Seyferts have L(H)/M ratios typical of starbursts, all Seyfert 1 galaxies in our sample have light-to-mass ratios similar to normal ellipticals and spirals.

Key words: **GALAXIES: ACTIVE — GALAXIES: STARBURST — INFRARED: GALAXIES**

1. INTRODUCTION

Dating star formation events in the nuclear region of galaxies is a fundamental tool for understanding their physical and chemical evolution and may shed light on the relationship between AGN and starburst activity.

Near infrared absorption features can be used to trace the cool stellar population which dominates the IR stellar luminosity of the galaxy and which is sensitive to a wide range of ages and metallicities. Red supergiants start to form around $\sim 10^7$ yr when O stars rapidly evolve towards the Hayashi track, whereas low mass red giants dominate the stellar luminosity of Population II stellar systems. CO features in the *H* and *K* bands, due to transitions in the second and first overtones respectively, also provide good estimates of the stellar chemical composition from intermediate to super solar metallicities as measured in galaxy bulges.

A major problem when dealing with integrated observables is the separation of age and metallicity effects because old and metallic stellar systems composed of low mass giants can have similar photometric/spectroscopic indices to younger and less metallic populations dominated by more luminous red supergiants. One possibility to separate the two contributions is to define age tracers which better represent the global properties of an integrated stellar population rather than being simply directly dependent on the stellar atmosphere parameters such as e.g., gravity and microturbulence. In principle these two parameters should be different in giants and supergiants but, since they also vary with metallicity, do not always provide unambiguous age indicators in practice.

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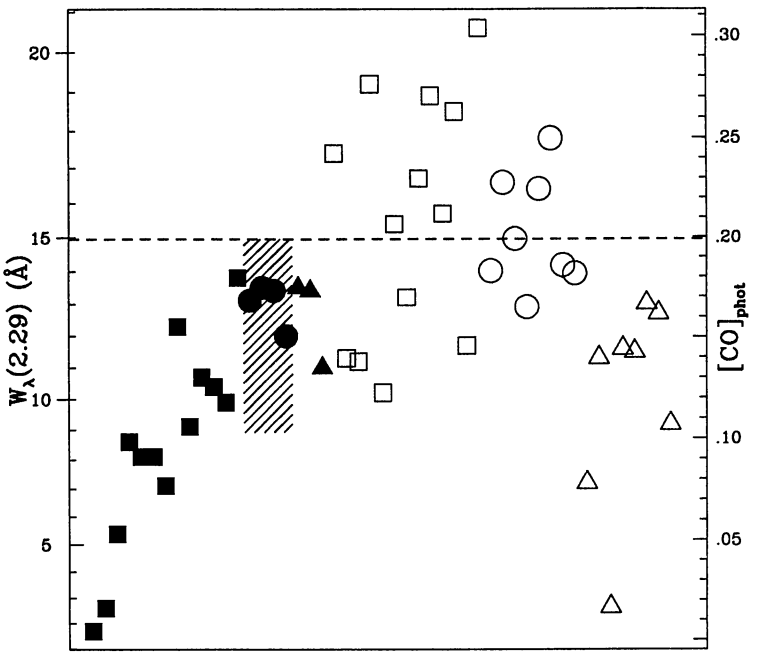

Fig. 1. Observed CO first overtone index in the K band for stellar clusters and galaxies in our sample. Along the X-axis from left to right are distributed: old Galactic globular clusters (filled squares) ordered by metallicity as quoted by Zinn & West (1984), ellipticals (filled circles), and normal spirals (filled triangles), Magellanic Cloud clusters (empty squares) ordered by decreasing age (Hodge 1983; Elson et al. 1987), starbursters (empty circles) and finally Seyfert 2 galaxies (empty triangles). All the galaxies are simply ordered by "NGC" reference number. On the left Y-axis are given the measured equivalent widths of our CO (2–0) index in Å which is the same spectroscopic index defined by Kleinmann & Hall (1986) in different units. On the right Y-axis the corresponding classical CO photometric index obtained with a simple linear transformation of the previous one (see Kleinmann & Hall 1986) is also plotted for comparison. The shaded area in the diagram is the range of values occupied by ellipticals in the CO photometric survey of Frogel et al. (1978).

A second major problem in active galaxies is the possible contamination by a non-stellar continuum due to dust and/or the Seyfert nucleus which may dilute the absorption features such that they mimic hotter stellar templates. In Oliva et al. (1995) we discussed a method based on spectroscopic color-magnitude diagrams to correct for this dilution and recover the correct mean spectral type. The differential dilution measured between the H and K bands also provides information on the nature of the non-stellar infrared continuum.

2. RESULTS AND DISCUSSION

Using the IR spectrometer IRSPEC at the ESO NTT 3.5-m telescope, we obtained near IR spectra centered at selected features of interest, namely Si I 1.59 μm, CO 1.62 and 2.29 μm and Brγ 2.17 μm, of a sample of normal spirals, ellipticals, starburst and Seyfert galaxies. From these spectra we obtained the line equivalent widths, velocity dispersions (our spectral resolution was ~60 km s^{-1}) and the surface brightness within a fixed aperture of $4.4'' \times 6.6''$ around the nucleus. As the distances to the galaxies in our sample range between a few Mpc and ~ 200 Mpc the region sampled varies but is typically a few kpc across.

The spectra of most of the Seyfert galaxies are diluted by a non-stellar continuum which is most probably due to hot dust at around 1000 K (see Oliva et al. 1995 for more details).

Using line equivalent widths alone it is very difficult to discriminate between age and metallicity effects. This is well illustrated by Fig. 1 where the CO first overtone indices for many of the known starburst and Seyfert 2 galaxies are clearly very similar to those observed in old, metal rich bulges. Although this index is very sensitive to the microturbulent velocity in the stellar atmospheres and certainly traces the presence of a red stellar population, it only reliably distinguishes between giants and supergiants in extreme cases. Its use for distinguishing young from old stellar populations in galaxies is also further limited by the effects of metallicity and possible dilution of the absorption features.

A more reliable tracer of starburst activity is found to be the L(H)/M light-to-mass ratio as inferred from the H band 1.6 μm luminosity and the dynamical mass estimated from the measured velocity dispersion. Based on a preliminary analysis, we found that elliptical and S0 galaxies show systematically larger velocity dispersions than starbursters as expected if the former are dominated by low mass giant stars and the latter by more luminous supergiants. All the known old galaxies have L(H)/M ratios between 1 and 3, while starbursters exhibit larger values between 5 and 14 and there are strong indications that when there is a central starburst it dominates the IR stellar luminosity, whatever underlying old stellar population is present, even at distances as large as 100 Mpc. Concerning Seyfert galaxies, all those of type 1 in our sample have L(H)/M ratios very similar to those of old galaxies whereas Seyfert 2's show a sort of bimodal distribution with some exhibiting values similar to type 1's while a few (like e.g., NGC 1068) have L(H)/M ratios between 5 and 8 indicating the presence of an old starburst in the nuclear region.

In order to confirm these distributions of the L(H)/M values we need to enlarge the statistics and to observe the most distant galaxies with smaller apertures in order to better isolate the nuclear region from the underlying bulge and old disk population.

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