1 up

NGL 50-002-044

ON THE He^+ TRIPLET LINE INTENSITIES

Get DRA

We wish to check the adequacy of theoretical calculations of helium triplet line strengths, including collisional enhancement, by comparing theoretical predictions with astronomical observations. A convenient way of doing this is to plot both on a (I(10830)/I(5876)) vs. (I(5876)/I(4471)) plane.

The calculations of Cox and Daltabuit (1971) are used for the 5876 Å and 4471 Å lines. For the 10830 Å line the parameters of Table 1 are used. The observations of line strengths are those of Peimbert and Torres-Peimbert (1971) and O'Dell (1963) for planetary nebulae and of Peimbert and Costero (1969) and Mendez (1967) for HII regions. The results are shown in Figures 1 to 4.

Figure 1 shows the theoretical line intensity ratios as functions of density and temperature.

Figure 2 shows that Peimbert and Torres-Peimbert and Peimbert and Costero's observations fit the theoretical predictions rather well, placing planetary nebulae and HII regions in separate density and temperature ranges. Figure 3 shows that O'Dell's and Mendez's observations do not disagree significantly with the theory, but perhaps show a systematic overestimation of I(4471). Figure 4 shows that the observational uncertainties are too large to indicate an error of the theoretical calculations.

Thus it appears that the theory of helium triplet line strengths agrees with present observations, and that the question of an additional depopulation mechanism for the 2^3S population is probably predicted correctly within 30%. The effect of this uncertainty, as well as the 50% uncertainty in the 5876 and 4471 collision cross sections was minimized in the Helium abundance calculations of Robbins, Daltabuit and Cox (1971) by comparison between 4471 and 5876 intensities and use of the cross section ratios.

Assuming that the $N(2^3S)/N(He^+)$ ratio is correctly calculated from the balance equations, we estimate the optical depth τ (3889) implied for the nebulae observed by Peimbert and Torres-Peimbert, using the temperatures and densities given by Peimbert (1971) and the radii given by Smith (1971) and Capriotti (1967). We find that the effects of self-absorption (Robbins, 1968) and collisional excitation on the intensity of the 7065 Å line at the predicted optical depths gives ratios of I(7065)/I(5876) which agree within observational and theoretical uncertainties for 6 out of 9 nebulae. This reinforces the feeling that the theoretical calculations are self-consistent.

A final check was made, using the method of Peimbert (1971) to see what effect temperature fluctuations might have on the contributions of recombination and collisional excitation to the He^+ lines. The results were that for normal temperatures ($\sim 10^4$°K) the effects could not distort the relative intensities more than a few percent nor will they alter the derived abundance of helium relative to hydrogen.

We thank M. Peimbert for his extensive and valuable discussions of this problem, D. E. Osterbrock for editorial comments, and the Institute of Astronomy, Universidad Nacional Autonoma de Mexico, for it's hospitality during the time when this work was done. This work was supported partially by NASA grant NGL 50-002-044, by the Universidad Nacional Autonoma de Mexico and by CONACYT (Mexico).

E. Daltabuit

D. Cox

Physics Department
University of Wisconsin
Madison, Wisconsin

References

Capriotti, E. R. 1967, Ap. J. 150, 95.

Cox, D. and Daltabuit, E. 1971, Ap. J. 167, 257.

Mendez, M. 1967, Bol. Obs. Tonantzintla y Tacubaya 4, 91.

O'Dell, C. R. 1963, Ap. J. 138, 1018.

Peimbert, M. 1971, Bol. Obs. Tonantzintla y Tacubaya 6, 29.

Peimbert, M. and Costero, R. 1969, Bol. Obs. Tonantzintla y Tacubaya 5, 3.

Peimbert, M. and Torres-Peimbert S. 1971, Bol. Obs. Tonantzintla y Tacubaya 6, 21.

Robbins, R. R. 1968a, Ap. J. 151, 497.

———— 1968b, Ap. J. 151, 511.

Robbins, R. R., Daltabuit, E., Cox, D. P. 1971, Ap. J. 169, L77.

Seaton, M. J. 1968, Adv. Atomic & Molecular Phys. 4, 331.

Table 1

$T \times 10^{-4}$	$\beta(2^3P) \times 10^{13}$ (1)	$q(2^3S - 2^3P) \times 10^7$ (2)	$\Upsilon_{CE}^{\infty}(10830)$ (3)
0.5	2.54	0.40	2.5
0.75	1.90	1.1	4.8
1.0	1.49	2.0	7.2
1.5	1.05	3.8	11.9
2.0	0.82	5.3	15.6

(1) Robbins (1968a)

(2) Seaton (1968)

(3) Computed using the formalism of Cox and Daltabuit (1971)

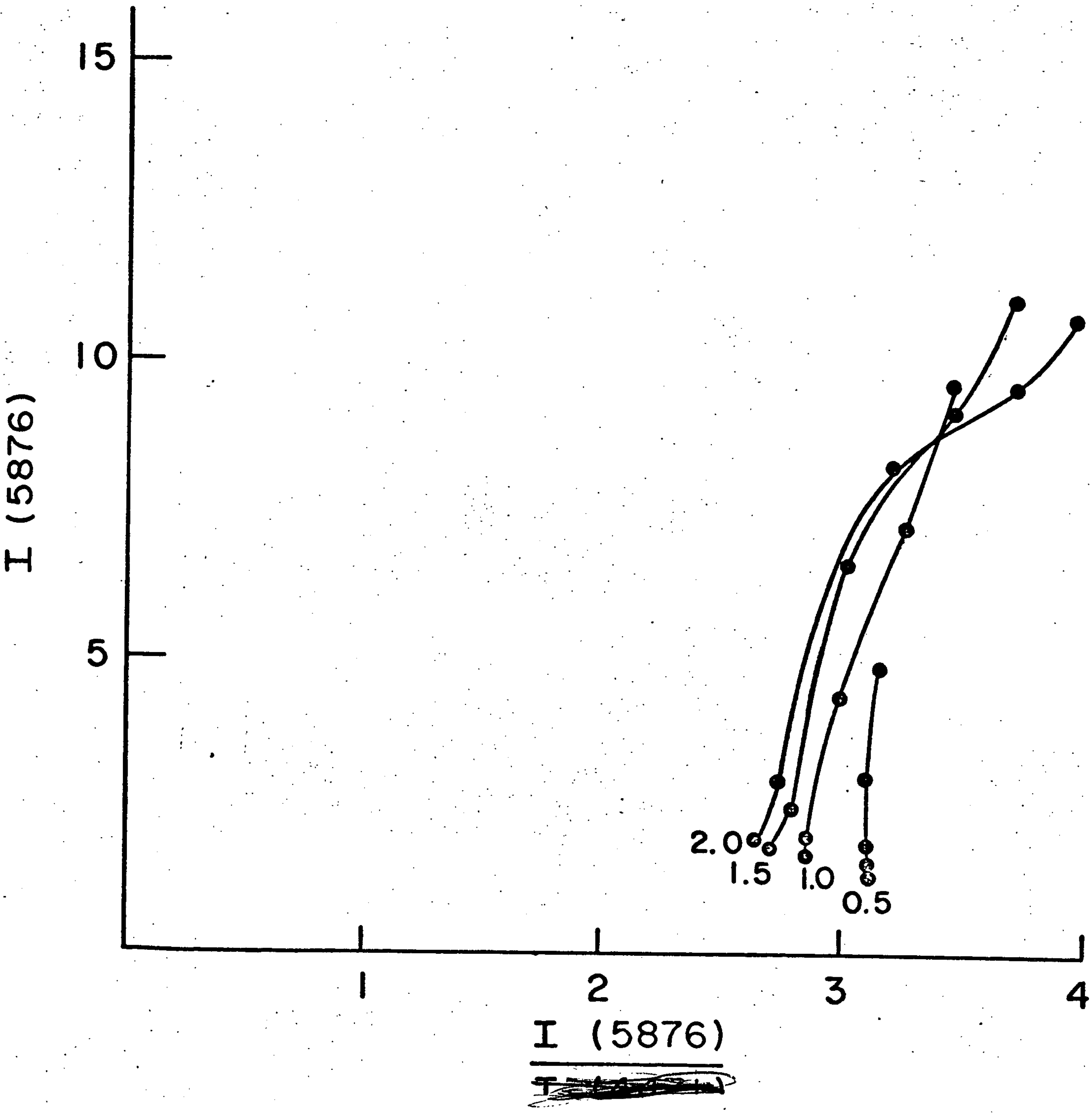
Figures

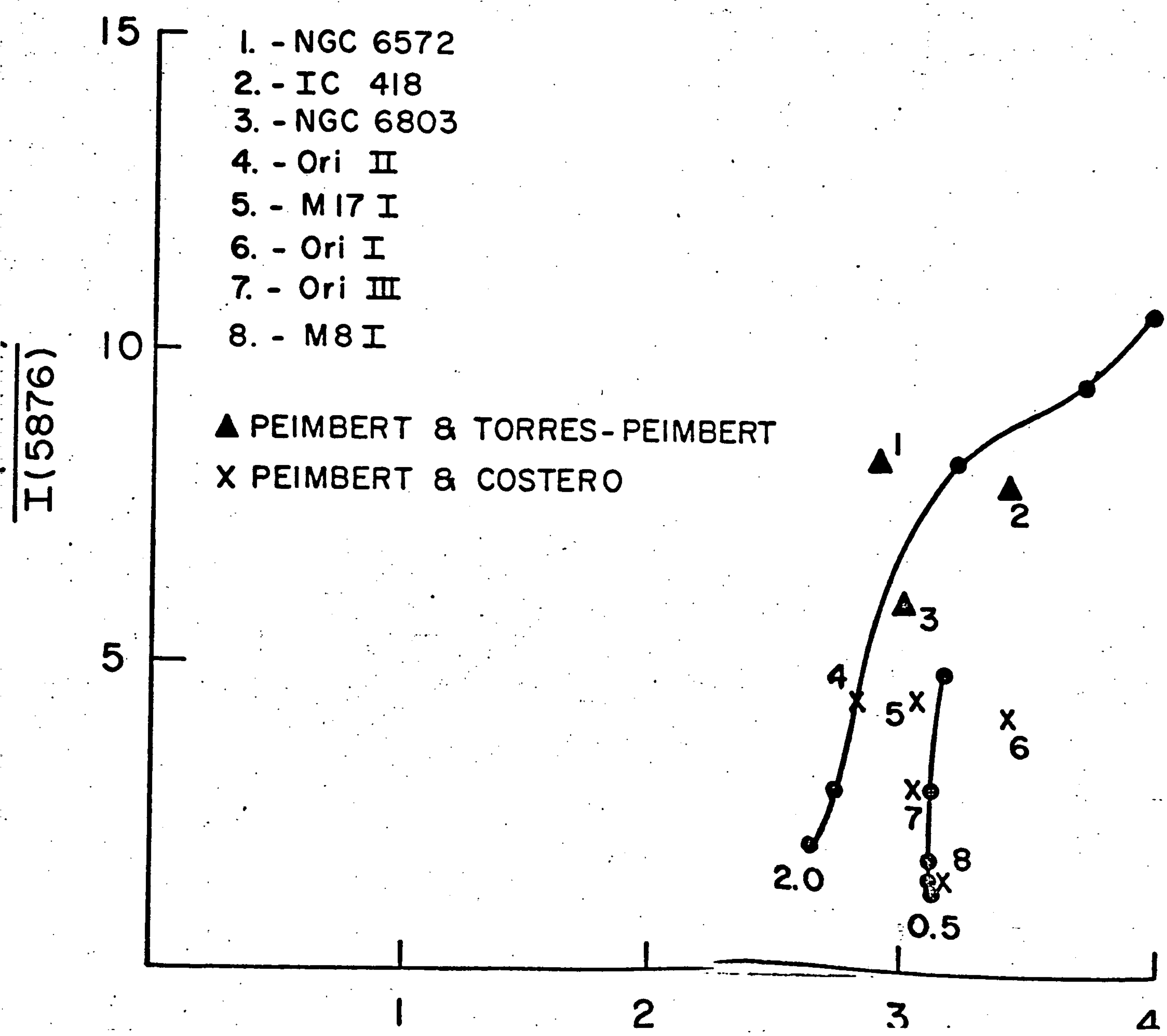
Figure 1 Theoretical calculation of line intensity ratios. The temperature for each line is indicated at the bottom of the line in units of 10^4°K. The density is indicated by the dots which correspond to 0, 100, 1000 and 5000 cm^{-3} going from bottom to top of each line. The uppermost points correspond to the infinite density case.

Figure 2 Comparison of recent observations with theory.

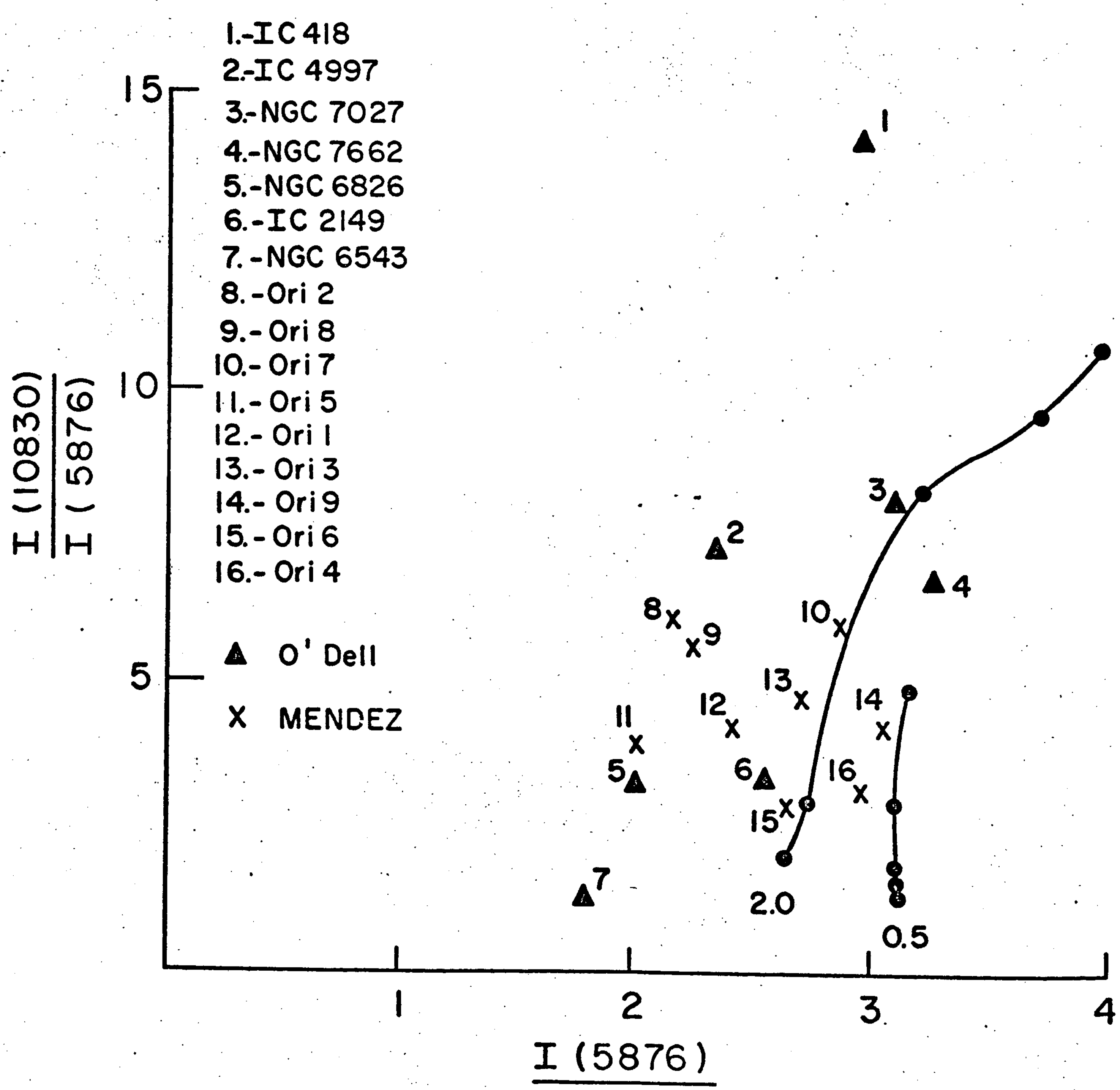
Figure 3 Comparison of previous observations with theory.

Figure 4 Comparison of planetary nebulae observations with theory. The observations are those of O'Dell and of Peimbert and Torres-Peimbert (See Figures 2 & 3). The error bars correspond to the uncertainties mentioned in the reports of the observations.

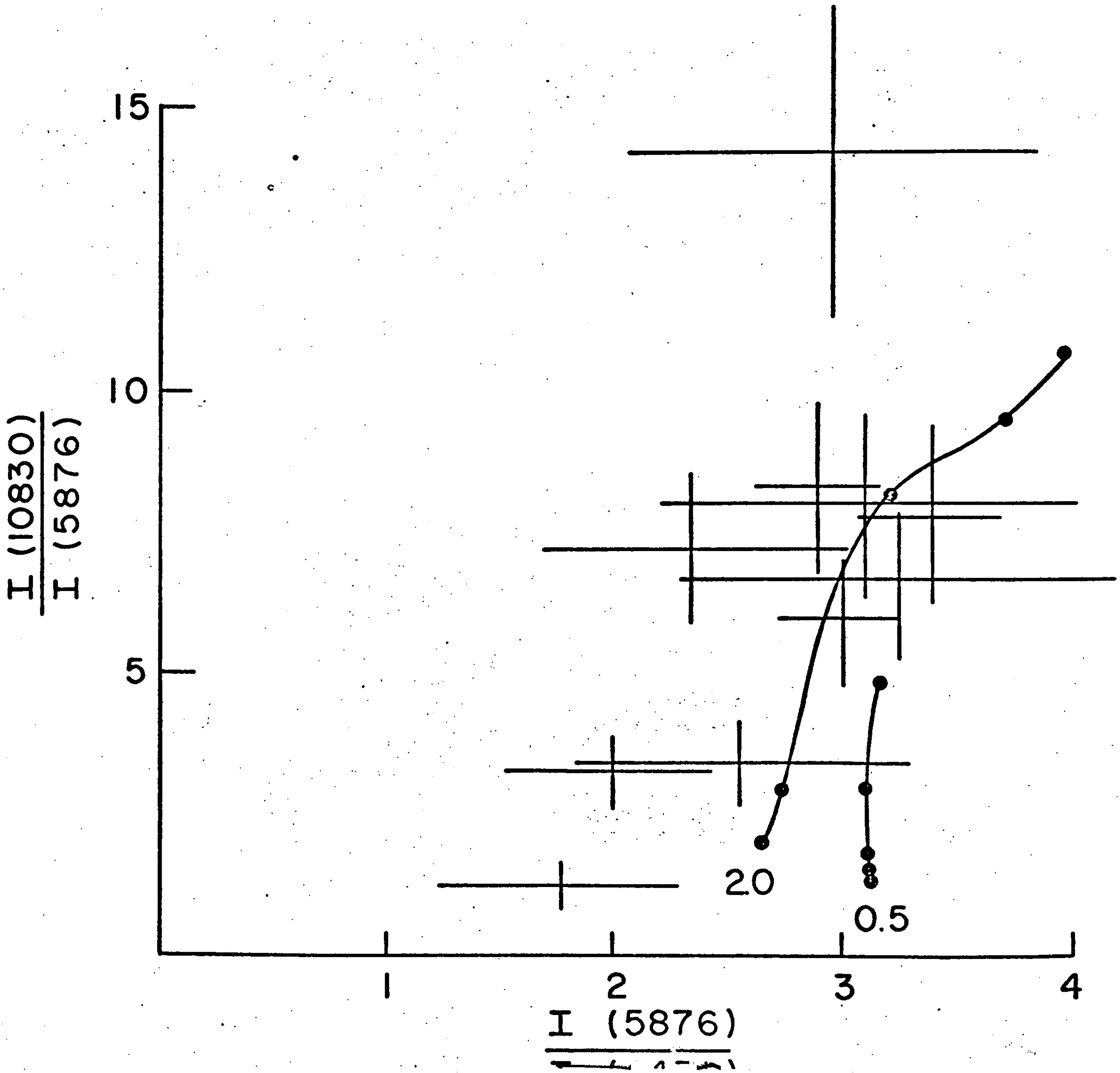

15
10
5
I (5876)
2.0
1.5
1.0
0.5
1
2
3
4
I (5876)



15
10
5
I(5876)
1. - NGC 6572
2. - IC 418
3. - NGC 6803
4. - Ori II
5. - M17 I
6. - Ori I
7. - Ori III
8. - M8 I
▲ PEIMBERT & TORRES-PEIMBERT
X PEIMBERT & COSTERO
2.0
0.5
1
2
3
4



1.-IC 418
2.-IC 4997
3.-NGC 7027
4.-NGC 7662
5.-NGC 6826
6.-IC 2149
7.-NGC 6543
8.-Ori 2
9.-Ori 8
10.-Ori 7
11.-Ori 5
12.-Ori 1
13.-Ori 3
14.-Ori 9
15.-Ori 6
16.-Ori 4
O' Dell
MENDEZ
I (10830) / I (5876)
I (5876)
2.0
0.5



15
10
5
I (10830)
I (5876)
2.0
0.5
1
2
3
4
I (5876)