A TYPE STARS AS PROBES OF THE LOCAL INTERSTELLAR MEDIUM

R. Freire Ferrero[1], R.Ferlet[2] and A.Vidal-Madjar[2]

1. Observatoire Astronomique,11 Rue de l'Université,67000-Strasbourg,FRANCE.
2. Institut d'Astrophysique de Paris,98 bis Bd.Arago,75014-Paris, FRANCE.

ABSTRACT.-

With the aim to sample well the Local Interstellar Medium (LISM),we propose to use A stars as targets. The Mg II UV lines seems to be the best interstellar absorption candidates. Several hundreths of A stars can be reached within 100 pc. First preliminary results (20 lines of sight) are presented, based on previous Copernicus and actual IUE observations.

I. INTRODUCTION.-

Typically, in order to study the gas in the interstellar medium (ISM), one uses rapidly rotating early type stars as background sources. For instance,UV observations with the Copernicus satellite have evidenced,through O VI sharp absorption lines, the existence of a pervasive,extremely low density ($n \sim 10^{-2.5}$ cm^{-3}) and high temperature ($T \sim 10^{5.5}$ °K) interstellar (IS)component which is quite local ($\lesssim$ 100 pc;Jenkins and Meloy 1974).This picture has been confirmed through diffuse X-ray observations.

Independent observational evidences have led several authors (e.g.Vidal-Madjar et al 1978;Bruhweiler and Kondo 1982;Tinbergen 1982;Crutcher 1982;Paresce 1983;Frisch and York 1983) to the conclusion that the Sun could be imbedded near the edge of small cold neutral IS cloud,which itself might be immersed in the observed hot component.

Nevertheless,O and B stars are distant and their lines of sight generally intercept several clouds with very different properties, making any analysis somewhat complex. Therefore,IS absorption has been observed with Copernicus and IUE toward much nearer late type stars but superimposed over stellar features. Despite the uncertainties due to the unknown intrinsic shape of the stellar profile, these results consistently pointed out a sharp drop-off in the hydrogen density ($\overline{n}_{HI} \sim 0.1$ cm^{-3}) beyond 3.5 pc of the Sun (see e.g. Mc Clintock et al,1978;Andersen and Weiler 1978). Furthermore,more recent IUE data on Mg II toward nearby white dwarfs (Bruhweiler and Kondo,1982) further support the above overall picture of the LISM.

However, all of these recent results appear to conflict with the model of Mc Kee and Ostriker (1977) in its present form (Bruhweiler and Kondo 1981) and much more additional lines of sight are needed before claiming that the current theoretical models have been adequately tested and in order to construct a detailed map of the LISM at a small scale length.

https://doi.org/10.1017/S0252921100098018 Published online by Cambridge University Press

II. OBSERVATIONAL STRATEGY.-

To refine our knowledge of the ISM in the immediate vicinity of the Sun, one must study many sight-lines toward stars closer than the O B type ones. Because the visual IS lines are limited to species of low abundances and/or low oscillator strenghts,the UV resonance lines are much more sensitive and thus better candidates to the study of the low column densities expected in the LISM.

We are thus facing the following alternative: to sample well the LISM we need cooler stars (presenting less emission in the UV) and strong UV resonance lines (more and more numerous when going toward the far UV). The best choice is thus to select the strongest UV line present at the largest possible wavelength: the Mg II doublet near 2800 A is obviously the best candidate.

Having selected this line, we simultaneously define the observatory to be used (IUE) and the target stars that should be selected. The observatory having a spectral resolution of $\sim$20 Km/s at 2800 A, this constraint imposes to use fast rotating background stars in order to avoid stellar feature contamination extremely difficult to resolve with this instrument. These condition leads clearly to the A stars and the hotter cool F stars as ideal target stars. In effet, from Allen (1982) one can easily show that within 100 pc from the Sun,several hundred target stars of that type could be found.

Another advantage of this approach is that a large sample of sight lines could be explored with a unique observational technique.This should thus lead to an extremely homogeneous observational set of data sampling in detail the LISM.

III. STARTING THE Mg II, A STAR SURVEY.-

Such an approach was performed first by Kondo et al (1978) who derived Mg II column densities toward 2 late B and 4 A stars (α Gru, α Leo and α CMa, α Lyr, α PsA and α Aql) observed with Copernicus. In that type of stars,the IS lines appear superimposed on the photospheric absorption profile of the stellar Mg II lines. Therefore,both will be more easily delineated when observing A stars with high rotational velocities. In general, rotation washes out the small differences in the computed line cores for different upper stellar atmospheric models and with the same abundances, giving convolved profiles that are more or less similar. But in the case of slow rotators,one can only measure crude limits on equivalent widths (W). Even if a detailed theoretical stellar profile can be computed in the frame of non LTE,with the assumptions of complete or partial redistribution Freire Ferrero,Gouttebroze and Kondo (1983) have shown that in the case of α Lyr (v.sin i = 17 Km/s) the previous determination of Kondo et al (1978) may be decreased by a large factor.On the contrary,preliminary computations by Freire Ferrero et al (1984) for Altair (α Aql,v.sin i = 220 Km/s) give IS Mg II equivalent width similar to the previous ones reported by Kondo et al (1978).

The present paper is a first step to sinificantly increase the sample of Kondo et al (1978): 14 A stars were observed in October 1982 and February 1983 with the long wavelenth camera of IUE (Freire Ferrero 1984;Freire Ferrero et al 1984a) out of which 10 are rapid rotators. Relevant stellar parameters along with Mg II equivalent widths are given in Table 1. More details can be found in Freire Ferrero (1984) and Freire Ferrero et al (1984).

We present here the first step toward a complete map of the LISM as seen through the Mg II lines in front of fast rotating A stars (Fig. 1).This study is still preliminary and for that reason only the quantity "equivalent width par parsec" (W/d) is presented.These values can underline quite clearly inhomogeneities in the LISM.

IV. DISCUSSION AND CONCLUSION.-

From this map,we can already underline the following main characteristics:

- the size of the sample is still too small to properly cover the LISM ;
- the general tendency found by other techniques is confirmed here,i.e. more matter seem to be present in the general direction of the galactic center,a drop in density beeing visible in the opposite direction.

This approach also shows fluctuation from line of sight to line of sight underlining the probable patchiness of the LISM. Before reaching such conclusions it is clear that a much larger sample of stars should be observed.This will be done by selecting properly target stars that will fill the large gaps present in the map, as well as stars which will allow a proper estimation of the precision of this approach. We think that when more than 100 A stars will be observed,a more detailed view of the LISM should arise.

V. REFERENCES.-

Allen C W 1981,Astrophysical Quantities,3rd ed,The Athlone Press,Univ London.

Anderson R C,Weiler E J 1978,Ap J 224,143.

Bruhweiler F C,Kondo Y 1981,Ap J Lett 248,L123.

Bruhweiler F C,Kondo Y 1982,Ap J 259,232.

Crutcher R M 1982,Ap J 254,82.

Freire Ferrero R,1984,in 4th European IUE Conf,Rome.

Freire Ferrero R,Gouttebroze P,Kondo Y,1983 Astron Astrophys 121,59.

Freire Ferrero R,Talavera A,Gouttebroze P,1984a,in 4th Europ IUE Conf,Rome.

Freire Ferrero R,Gouttebroze P,Catalano S,Talavera A,1984b,in preparation.

Frisch P C,York D G 1983,Ap J Lett 271,L59.

Jenkins E B,Meloy D A 1974,Ap J Lett 193,L121.

Kondo Y,Talent D L,Barker E S,Dufour R J,Modisette J L,1978,ApJ Lett 220,L97.

Mc Clintock W,Henry R C,Linsky J L,Moos H W,1978,ApJ 225,L65.

Mc Kee C F,Ostriker J B,1977,ApJ 218,148.

Paresce F 1983,Nature 302,806.

Tinbergen J 1982,Astron Astrophys 105,53.

Vidal-Madjar A,Laurent C,Bruston P,Audouze J 1978,ApJ 223,589.

https://doi.org/10.1017/S0252921100098018 Published online by Cambridge University Press

TABLE 1

H D	name	Sp T	l	b	d(pc)	v.sin i	W_k(mA)	W/d	Fig.1 N°
48915	α CMa	A 1 V	227.22	- 8.88	2.67	11	71	26.6	1*
87901	α Leo	B 7 V	226.43	48.94	25.6	330	95	3.7	6*
172167	α Lyr	A 0 V	67.44	19.24	8.13	17	70	8.6	4*
187642	α Aql	A 7 IV-V	47.74	- 8.91	5.05	220	142	28.1	2*
209952	α Gru	B 7 IV	350.	-52.47	19.6	240	170	8.7	5*
216956	α PsA	A 3 V	20.49	-64.90	6.94	100	133	19.2	3*
19832	56 Ari	B 9 p Si	157.68	-25.95	140.**	115	300	2.1	15
28910	ρ Tau	A 8 V	182.05	-21.67	38.5	125	65	1.7	10
91312	- -	A 8 IV	178.93	58.62	32.3	135	<50	<1.	19
95934	51 Uma	A 3 III-IV	179.75	65.03	70.**	100	150	2.1	12
106661	6 Com	A 3 V	267.16	75.25	38.5	175	80	2.1	9
127762	γ Boo	A 7 IIIvar	67.26	66.17	40	145	<50	<1.	20
135382	γ Tra	A 1 V p	315.71	- 9.55	100.	225	255	2.6	14
139006	α Crb	A 0 V	41.87	53.77	22.2	135	95	4.3	8
159561	α Oph	A 5 III	35.90	22.57	14.9	230	160	11.	16
205767	ξ Aqr	A 7 V	46.45	-40.34	83.3	165	135	1.6	13
11753	φ Phe	A 3 V	267.17	-69.99	64.**	15	<50	<1.	17
28978	- -	A 2 V	190.32	-27.08	78.**	15	<50	<1.	18
155125	η Oph	A 2 V	6.72	14.01	19.2	<10	150	7.8	7
214994	o Peg	A 1 IV	91.71	-25.59	41.7	10	150	3.6	11

* Kondo et al (1978) observations.

** distances deduced photometrically.

https://doi.org/10.1017/S0252921100098018 Published online by Cambridge University Press

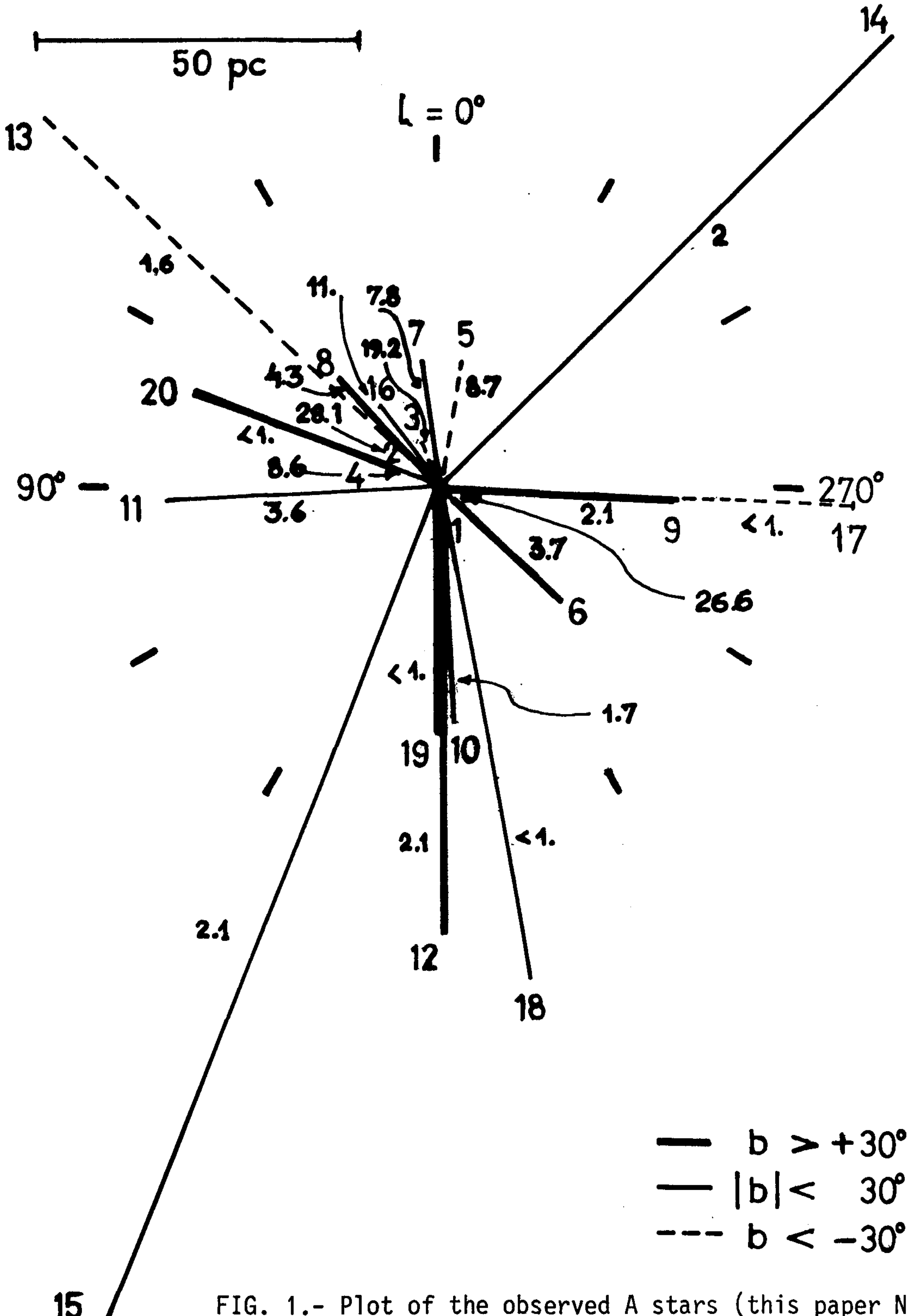

FIG. 1.- Plot of the observed A stars (this paper N°7 to 20) and the Kondo et al (1978) observations(N°1 to 6).The values (mA/pc) of W/d (only upper limits for slow rotators) are also indicated beside each sight-line.

https://doi.org/10.1017/S0252921100098018 Published online by Cambridge University Press