# *On the λ4430 Absorbers in "Normal" and in Perturbed Clouds*

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REGIONS PERTURBED BY EARLY-TYPE STARS are characterized by the occurrence of high Ca II velocities and an increase in the abundance ratio Ca II/Na I (ref. 1), by a decrease in the λ4430 absorption to color excess (ref. 2), and possibly by a deficiency of small relative to large grains (large values of the ratio of total extinction to color excess, $A/E$). According to reference 3, the grain temperatures in the same regions are expected to be higher, and therefore may lead to selective evaporation of the smallest grains. Since these observations may be connected by way of λ4430 absorption originating in very small grains, it is of interest to compare the value of $nf$ (number of absorbers times $f$/value) of the λ4430 absorbers with the number of molecules $n_{mol}$ in the grains responsible for extinction in the visible. Based on the observed mean equivalent width of 3 Å kiloparsec in the λ4430 band, the value of $nf$ (4430) is

$$nf(4430) = 1.7 \times 10^{13}/\text{cm}^2\text{-kpc} = 6 \times 10^{-9}/\text{cm}^3$$

With a grain density of $10^{-26}$ g/cm³ and $3 \times 10^{22}$ molecules/cm³ in the grain material, $n_{mol}$ is

$$n_{mol} = 10^{18}/\text{cm}^2\text{-kpc} = 3 \times 10^{-4}/\text{cm}^3$$

Therefore, the relative abundance of λ4430 absorbers is

$$nf(4430) = 2 \times 10^{-5} n_{mol}$$

and the λ4430 band can be explained by reasonable $f$/values and by moderately abundant species. In particular, it might be caused by resonance line absorption of some minor grain constituent, since, for example, 20 parts per million of Ca I or Ca II in the smallest grains would suffice to account for the observed absorption intensity. It should be emphasized that this is a very ingenious hypothesis in that it speculates that among other possible atomic or molecular absorbers, the 4430 Å line might be caused by the resonance line of either Ca I or Ca II. Both of these qualify by having a resonance line very close to 4430 Å, and the resonance lines of both have *f*-values of the order of unity. Therefore, 4430 Å bands can be produced by putting calcium atoms or singly ionized calcium into some solid material. I think the kind of solid would be immaterial.

The hypothesis that the 4430 Å resonance line might be caused by Ca II would be quite difficult to disprove in the laboratory. The element Ca I might be a good suggestion also, but this hypothesis can be checked with relative ease in the laboratory by condensing neutral calcium atoms that are evaporating out of an oven onto a cold window simultaneously with some other material. Indeed, some preliminary observations have already been carried out; Dr. Schnepp in Israel found some more or less continuous absorptions in the visual and the ultraviolet by using calcium atoms in various ice-type solids while nothing showed up at 4430 Å. However, it was not known in those experiments whether the calcium atoms were single atoms or whether they tended to conglomerate into small calcium particles. In any case, I think Ca II is a very good suggestion.

In an investigation reported in reference 2, I found that the correlation between λ4430 absorption and color excess can be improved by separating stars into two groups: those showing high-velocity Ca II interstellar lines and those showing no such high velocity. With this separation one finds those stars showing the high-velocity clouds predominantly in the lower section of the diagram, whereas the remaining stars are predominantly in the upper part.

Another interesting way of improving this correlation would be to separate the stars according to the two types of reddening curves, as observed, for example, in Cygnus and in Perseus.

## REFERENCES

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3. GREENBERG, J. M.; and LICHTENSTEIN, P. R.: Absorption Lines Produced in Interstellar Grains. Astron. J., vol. 68, 1963, p. 279.

## DISCUSSION

**Spitzer:** Your suggestion about Ca II brought to mind the similarity between Ca II and Mg II. Could you guess as to possible effects of Mg II?

**Dressler:** In order to produce a 4430 Å line, we need a fairly abundant

https://doi.org/10.1017/S0252921100118354 Published online by Cambridge University Press

species or one that has a line with a very large *f*/value originating in the line is near 2800 Å.

**Spitzer:** I wasn't thinking of Mg II producing this line, but if Ca II produces the 4430 Å resonance line, Mg II might produce a line that we could measure in the ultraviolet.

**Walker:** I am not entirely convinced about the differences between the correlation of λ4430 and reddening for stars showing normal interstellar calcium velocities and those showing high calcium velocities. I find that if I introduce data that Dr. Münch obtained in Israel, the correlation you found disappears. The two lines in your diagram are actually parallel; they don't diverge from the origin.

**Dressler:** Yes, and we like that fact in particular because it indicates that the hot star affects just the material nearest to it, whereas all the rest of the material is unperturbed. There is just one cloud lacking the λ4430 absorption.

**Walker:** I just wanted to suggest that perhaps it depends on exactly how one chooses the data. I don't know what resolution you would want. The higher resolution plates which Münch used picked up more satellite lines of calcium; there practically all the associations show a relative expansion of calcium velocities, and so the correlation does disappear if you restrict it to the stars in the Milky Way. However, if one is only dealing with very strong expansion components, perhaps your conclusion is reasonable.

**Dressler:** Yes, it is just a question of where one does divide between stars having or not having sufficient power to produce high-velocity Ca II.

**Borgman:** It is always possible to explain the scatter by introducing a sufficient number of parameters that might have some influence, whether you understand the physical machinery or not. It is always dangerous to do this and one should be very careful.

**Wampler:** The star NGC 2244 shows strong 4430 Å resonance indeed, but I have measured several of the field stars in the neighborhood of NGC 2244, and they also show strong 4430 Å resonance. At one time I was rather excited about the possibility of a relation between longitude and the λ4430 absorption, and perhaps it is still there. Certainly the stars in the Taurus complex show weak 4430 Å resonance, but this type of change in the 4430 Å wavelength region greatly overwhelms any possible correlation of longitude.