Scanner Observations of $\lambda 4430$

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The interstellar band at λ4430 has been observed in over 100 stars by using the Lick Observatory scanning spectrograph mounted on both the 120-inch telescope and on the Crossley telescope. Although in some instances the feature is badly blended with stellar lines, particularly with early B supergiants, in general the central depth of λ4430 has been determined to an accuracy exceeding 0.5 percent of the stellar continuum.

The feature has been found to have a fairly symmetrical profile, although there may be changes in the profile from star to star. The extended wings reported by other observers were not detected, and also the feature does not seem to be polarized.

The correlation between the absorption band at λ4430 and color excess is not one-to-one. Even field stars lying in the galactic plane show much intrinsic scatter in the ratio of this absorption band to color excess. For some clusters, a change in the slope of the correlation between λ4430 and color excess can be interpreted as caused by local variations in the ratio of λ4430 absorption to interstellar dust absorption. However, these differences are not well correlated with the values of the ratio of absorption to color excess A_v/E that are reported in reference 1. Also there are quite large local variations in the ratio of λ4430 to color excess that cannot be interpreted as caused by local destruction of the source of λ4430 by hot stars.

The absorption band at λ4430 definitely appears to be weakened in dust clouds that lie outside the galactic plane. This weakness may indicate that the agent causing λ4430 is more closely confined to the plane than the dust, or that it has been destroyed in the high latitude clouds, or that the conditions for forming the atomic states responsible for λ4430 are unfavorable in these clouds. The scatter in the relationship between absorption at λ4430 and color excess as well as the probable detection of this absorption in ρ Leonis indicates that this absorption may be produced by an agent of the interstellar medium other than that which causes the extinction.

REFERENCE

1. Johnson, H. L.: Interstellar Extinction in the Galaxy. Astrophys. J., vol. 141, 1965, pp. 923–942.

DISCUSSION

Donn: Are there any instances of strong λ4430 but weak color excess?

Wampler: Possibly ρ Leonis. Also, in general, the regions in Monoceros have strong λ4430 for their color excess. There is no example as outstanding as ρ Leonis that I know of. This is just one case and, of course, the color excess of ρ Leonis may be in error because it is small.

Greenberg: In a recent calculation I have assumed that the λ4430 extinction is one-twentieth of the total interstellar extinction at λ = 4430Å. What is the maximum that has been observed?

Wampler: According to Dr. Herbig of the Lick Observatory, the absorption at λ4430 is probably 18 percent deep in HD 183143. I think the color excess is about 1.4. Assuming a ratio of total to selective extinction of 3 yields a value of A_v of 4.5 magnitudes. Another 1.4 magnitudes must be added because of the $B-V$ color.

Greenberg: Yes. Now, roughly speaking, the percentage is one-tenth of a magnitude.

Wampler: For λ4430 absorption of 0.18 and 6 magnitudes of extinction at λ = 4430 Å, the ratio of λ4430 to extinction would be 0.18/6, or approximately 0.03.

Greenberg: It looks like the maximum ratio is about 1:25.

Walker: I did observe one star with about 25 percent central absorption at λ4430 for 1 magnitude of color excess; it was HD 46711.

Greenberg: Maybe this could be checked later, because I would like to see whether the numbers that I have are meaningful in the sense that they can explain the maximum. If the 5 percent is a reasonable maximum, then a surface phenomenon is not unreasonable.

Wickramasinghe: What is a surface phenomenon?

Greenberg: I am assuming that various (as yet undetermined) molecules may form on the surface and may even be somewhat transient as long as they are present for a sufficient fraction of time. I can say either that they have to occupy roughly 5 percent of the surface all the time or that they have to cover the entire surface only 5 percent of the time.

Wampler: Because scatter is seen for stars in the galactic plane, one might assume that there is a difference in strengths of λ4430 absorption between clouds; that this difference could be rather large; and that it could produce the scatter. A fairly good mean relationship can be obtained by looking through several clouds. High galactic latitude clouds on both sides of the plane all show weak absorption at λ4430. Although some of them show the λ4430 as strong as the mean line,

https://doi.org/10.1017/S0252921100118342 Published online by Cambridge University Press

none show λ4430 stronger than the mean line, and the majority show λ4430 considerably weaker than the mean line. Perhaps this is a clue.

O'Dell: In the case of NGC 2244, since the ratio of total to selective extinction can be different in certain regions, would it not be better to look at the strength of λ4430 as a function of absorption instead of color excess? This might provide a better measure of the total amount of dust, and would tend to shove NGC 2244 systematically over to the right. Would this make the overstrength of λ4430 tend to disappear?

Wampler: It would indeed. On the other hand, it would make λ4430 appear even weaker in Orion than it already appears.

Dressler: Is breaking some solid material up into very small grains equivalent to spreading it out into a thin layer as far as its optical absorption properties are concerned?

Greenberg: If the absorption occurs in a sufficiently thin layer, then to the first approximation the inside of the grain sees almost the undisturbed incident radiation; consequently, the extinction is additive. That is, the extinction at λ4430 and the extinction by the grains are additive.

Dressler: Hence, would some macromolecule which did have an absorption line at λ4430 show up in the same way either as a thin layer or as a very small grain?

Greenberg: I would think so. There are problems associated with shifts of the wavelengths when one material is embedded in a material of different optical properties.

Dressler: Were the photoelectric profiles that you showed for λ4430 raw data or were they corrected for stellar absorption lines?

Wampler: These profiles are not corrected for stellar absorption lines. The only change that has been made to the raw data has been to take out the slope of the continuum. Some of the scatter was due to stellar atomic lines. The star HD 183143 shows a little dip at λ4437 due to He I and some of the stars show O II. Of course, ρ Leonis shows very strong O II because it is an early B supergiant.

For illustration I picked stars in which there were no strong atomic features. I tried not to pick the B supergiants. A profile for B supergiants would have looked much messier.

Hall: What figures did you get for NGC 2244? Do you remember those?

Wampler: As well as I can remember the λ4430 is 6 percent. The λ4430 profile for all the stars in this cluster looks somewhat peculiar; it looks like the star has emission wings. The absorption at λ4430 becomes a little stronger if you assume that the continuum is on these "wings" than if you take a continuum as derived from points 50 or 100 Å away from λ4430.

Hall: Did you try polarization?

Wampler: I didn't try polarization for these stars. The only polarization I tried was for the two stars that I mentioned. The difficulty is that polaroids cut out a lot of light, and with a 6 Å exit slot there is not much light.

Walker: Could you possibly say anything more about the differences in profiles between different stars? In photographic reduction of plates for λ4430 I have frequently seen a kink near λ4471. I had assumed it was something caused by the emulsion response, but it looks as if it must be due to an astronomical effect.

Wampler: I have drawn some profiles that occur quite often. Typical profiles for NGC 2244 show that in some of the stars the blue wing is steeper than the red wing, but that in other stars the opposite is true. At present I am undecided as to whether this difference is due to λ4430 or perhaps to some other broad interstellar feature that might be overlapping λ4430, or due to the stars themselves. I have also compared the absorption in the ultraviolet wing with that in the red and plotted this as a function of the central depth of λ4430. The results showed very large scatter with a slight tendency for the red wing to be deeper. At the time, I decided that this trend could probably be explained in terms of the helium wings; but there may really be an asymmetry in the profile.

Nandy: Did you apply corrections for reddening when you derived the continuum?

Wampler: I think any effect is small. I can show you the observations in the raw form and you can draw your own conclusions. The continuum points were as follows: λ4285, λ4305, λ4310, λ4359, λ4378, λ4495, and λ4527. The choice λ4527 may not be a very good one because there are nitrogen features in early-type stars nearby. I suspect that they influence this point. In general, if one fits a straight line to these points, that line comes very close to the wings of λ4430. Although there may be some curvature, I think that this is less than 1 percent of the depth of the λ4430 absorption.

https://doi.org/10.1017/S0252921100118342 Published online by Cambridge University Press