Re: Solar absorption lines

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- *From*: willner@xxxxxxxxxxxxxxx (Steve Willner)
- *Date*: 10 Jul 2006 17:34:37 −0400

In article <44ae6c8c$0$22360$afc38c87@xxxxxxxxxxxxxxxxxxxx>,
Scott <ss@xxxxxxxxxxxxxxxx> writes:

> What process causes absorption lines in solar spectra (when measured from above the Earth's atmosphere)?

> From your subsequent posts, I suspect you are thinking of low−density

plasmas. (So, I suspect, are several people who have replied.) Stellar atmospheres are different because they are a lot denser. The buzzword would be that (to a first approximation) you have "local thermodynamic equilibrium," not "detailed balance." In other words, a common physical process is that a photon is absorbed and excites an atom. The atom then decays _not_ by radiation but by a collision, imparting the extra energy to an atom or ion nearby. Of course the inverse process also occurs, but it's less common because there is a net transfer of energy outward. This gives absorption lines without creating corresponding emission lines in other directions.

There's also a geometric issue. Most spectra of the Sun are of a small area of the disk, so you wouldn't see the "balancing" emission lines in these spectra even if the lines existed. However, this is not the major effect. There are some "whole−disk" spectra of the Sun, and of course there are plenty of whole−disk spectra of sunlike stars that show absorption lines. (Postings about the chromosphere "flash spectrum" are correct, but the net emission doesn't come close to balancing the absorption as can be seen in the whole−disk spectra.)

The best way to start thinking about stellar atmospheres is a "plane−parallel" model. Imagine a single square centimeter on the surface of the Sun and a very long column below it. At any depth, the gas has a fixed temperature and density, the same in all horizontal directions, but density and temperature both increase as you go down. (We ignore the temperature inversion; absorption lines are formed below it, so for this purpose just take the temperature minimum as the "surface.") Do you see why this model has to produce absorption lines as viewed from above? If so, your question is answered. If not, do you understand the concept of "optical depth?" That's the key to answering your question in more detail than in the first paragraph.

If you want to understand this at a serious level, you will need to find a textbook. Dimitri Mihalas and John Jefferies are two authors who have written good texts, but there may be even better ones around these days. (No prizes for guessing how long it has been since I actually studied this stuff!)

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