

The Sun's Corona temperature

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Summary:

This brief article explains how a 5000 degree surface of the sun is able to heat the sun's corona to a temperature higher than 1 million degrees. The explanation is made for everyone to understand and an experiment is described on how to heat something in a similar way to a temperature higher than the source temperature here on earth.

There is a mystery around the sun's corona temperature. At high altitude, the sun's atmosphere is over a million degree Kelvin while the surface of the sun is only about 5000 kelvins. This is counter-intuitive because heating something at a temperature about 500 times higher than your own temperature seems odd when you don't know what really happens there.

The three usual way of transferring heat to an object here on earth is by contact, by convection and by radiation. The sun's corona doesn't transfer a significant amount of heat using contact because it's in space. Convection plays a role because of the solar winds but it's rather small, it doesn't evacuate a significant proportion of the energy stored in the corona. Radiation as we would expect is the preferred method the sun uses to release it's energy.

When convection or contact is used to transfer energy, it seems hard to heat something to a temperature higher than the source of heat. Using radiation however, things get different. The object that receives the energy doesn't really care that the source of energy is hot or cold. The only thing it cares about is that if it receives more energy than it can give back, then an object's temperature should increase.

The sun's corona is a few thousands km away from the surface of the sun, but the radius of the sun is about 700,000 km. A sphere of 700,000 km radius would be hard to distinguish from one of 710,000 km and would have a similar surface area. That means that the energy density that passes the surface of the sun is similar to the energy density that the corona receives. A single electron on the surface will receive a little bit more radiation than an electron in the corona but the difference is small.

Let's look at the facts to compare an electron at the surface and one in the corona:

- Both electron are in plasma so they should absorb radiation energy in a similar way.
- Radiation is the preferred method to receive energy.
- Radiation is the preferred method to release energy.
- Both electron receive a similar amount of energy because the density of radiation is similar.
- Temperature is much higher in the corona.

It seems logical to say that the only difference should be that an electron in the surface is able to release radiation more easily than an electron in the corona.

Now we should ask ourselves what causes an electron to radiate energy? The usual way of explaining this is to say that the electron is in an "unstable" orbit and it wants to go back to a stable orbit. What could trigger such an orbit change for an electron? If you think the universe likes randomness then you are wrong. When an electron has an orbit that goes far from the nucleus, it has more chances of closely interacting with an

electron from a nearby atom. That interaction will surely change the path for both electrons and their orbit will change. Each interaction with a nearby electron gives an opportunity for an electron to change its orbit and therefore an opportunity to release energy.

Knowing that each interaction gives an opportunity to release a photon it is easy to see that electrons on the surface of the sun have plenty of opportunity to release their energy in the form of light, because the density at the surface is extremely high. However, for the corona which has a very low density, the opportunities to interact with other electrons are scarce. They cannot release energy often. This means that if they were at 5000 Kelvin, they would not release all the energy they receive so they would heat up. At over a million Kelvin, they interact more and each photon released will contain a lot more energy. This is why the temperature stabilized and why such a high temperature is needed to balance the energy received vs the energy released.

Instead of seeing the fact that the corona has a higher temperature as a mystery, we should see this as a hint on how the universe is working. In that case, it's a clear hint that an electron will release radiation because of its interaction with nearby electrons and that these interaction gives them opportunities to release some radiation.

Someone with a scientific approach might wonder if this could be tested, if we could have an experiment done that would confirm this. The answer is yes. Using vacuum chambers to change the density of a gas it would be hard because the glass walls of the chamber would interact too much with the gas inside. A simpler test would be to use two solids inside a vacuum chamber. Both objects would not give away heat by convection or contact so radiation would be the only way they can release their energy. Solid A would be heated using electricity so it would received a stable amount of energy and would eventually radiate a stable amount of energy when its temperature stabilize. Solid A would radiate most or all of its energy towards Object B. Object B must be able to absorb the radiation from Object A but it should not radiate as much. I presume that an object with a much higher melting point would radiate less. In that experiment, Object A would have a stable temperature because it radiates as much energy as it receives. Object B would receive a similar amount of heat as object A and it needs to absorb most of it. Since Object B will not radiate as much as Object A, then it will eventually raise its temperature until it is able to radiate more energy. You will have heated object B to a temperature higher then the source of heat.

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