**Thermal Distribution of Hydrogen atoms**

From <http://astro.unl.edu/naap/hydrogen/abundances.html>

**One Atom vs. Many Atoms**

When an atom is by itself, in isolation, its orbitals behave differently than when in packed tightly with other atoms. For example, the energy levels of a single carbon atom are slightly different than a diamond. Similarly, hydrogen gas (H2) is a tiny bit different than a simple H atom. The difference in energy levels, however, is not much in that case. The Hydrogen Atom Simulator showed just one H atom.

Astronomically one H atom is *never* observed. Rather, only vast numbers of Hydrogen atoms together are observed. Often they atoms (or H2 molecules) are on average far enough apart so that the orbitals aren't significantly altered. Another way of saying that is the density is “low”. But even when the density is low (which we will assume here), there are the occasional collisions between the atoms. When they collide some of the energy goes into them bouncing off of each other and some of it can go into exciting electrons. How frequently collisions occur and how much energy typically goes to exciting the atom depends on how fast the low density cloud of hydrogen atoms are moving on average. A way to measure the average speed of the atoms with respect to each other is *temperature*.

**Thermal Distribution**

The histogram is of 1025 Hydrogen atoms. The density of the atoms is low so that their energy levels are very close to what we see for a single atom. The temperature can be varied from 3000 K to 30,000 K (a range which includes the surface temperature of almost all stars). Experiment with the slider.

* Note that at 3000 K almost all of the atoms are in the ground state.
* Note also that at 3000 K there are more ionized atoms than there are atoms with electrons in the 2nd orbital. As the temperature is increased the disparity between the number of ionized atoms and level 2 atoms will become even larger. This occurs because of the energy spacing of the levels – an electron in level 1 is much more tightly bound than one in level 2. Collisions between atoms that are sufficiently energetic to knock the electron from the ground state to level 2, but not sufficiently energetic to ionize that atom become rare as the temperature rises.
* Note also that the histogram is logarithmic and the relative heights of the bars behave in a non-intuitive fashion. For example, at 20,700 K the ionized atom bar is only about 20% higher than the level 1 bar but there are 10,000 ionized atom to every level 1 atom.

