

Re: one billionth degree above absolute zero, how did they measure it?

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John Smith wrote:

The lowest temperature achieved in the lab is one billionth degree above absolute zero. How is this temperature measured and how precise is the method? Any references would be greatly appreciated.

That's a good question— and it shows that a common-sense idea about 'temperature' can't be extrapolated down to these values.

First, recall that thermodynamics and statistical mechanics has a fundamental relationship between energy and temperature, encoded in terms like $\exp(E/kT)$. One result is that temperature is actually a logarithmic scale— getting to a temperature of 0 K requires infinite energy. Also, the precision of the measurement isn't as amazing as it may seem.

Another result is that 'temperature' has less to do with how hot or cold something is, but how the energy in a collection of objects is distributed. For example, take 100 atoms, each with 1 femto-erg of energy. That's our common sense idea of atoms at about 7 K. Now, let's elastically collide the atoms together somehow so that one atoms ends up with nearly all of the 100 femto-ergs of energy, while the others have nearly no energy. Then remove that single atom. The remaining atoms are much 'colder', meaning they have much less energy.

I couldn't easily find any good references, but atom trapping experiments, which are presumably what you read about, assign temperature by measuring energy, specifically energy shifts by collision with carefully tuned 'cooling' lasers. And these temperatures are of very small numbers of atoms, not something macroscopic. The experiments are also done in a vacuum, so air atoms at 300 K don't collide with and heat up the cold atoms.

There's a lot on low-temp physics and methods on the web: magnetic cooling, spin cooling, laser cooling, etc. that have nothing to do with putting a sample in thermal equilibrium with, for example, liquid helium.

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