

Re: The temperature of a photon ?

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- *From:* "Peter Christensen" <PeCh@xxxxxxxxxxx>
 - *Date:* 20 Sep 2006 02:17:45 -0700
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mmeron@xxxxxxxxxxxxxxxxxxxx wrote:

In article <1158142120.208363.61430@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx>, "Peter Christensen" <PeCh@xxxxxxxxxxx> writes:

mmeron@xxxxxxxxxxxxxxxxxxxx skrev:

In article
<44fd41e7\$0\$75040\$14726298@xxxxxxxxxxxxxxxxxxxx>,
"Peter Christensen" <PeCh@xxxxxxxxxxx> writes:

Does it make sence to talk about the
temperature of a photon? (-My own
answer is no.)

A photon, no. Photons, yes.

Agree.

It always applies that $E = p \cdot c$ (p is the
momentum which depend only on the
wavelength) for a photon. But as the speed
of light is always c , there can't
be a kinectic energy as for massive particles,

Oh, of course there can be kinetic energy. All of photon's
energy is
kinetic.

I don't think about it like that, but I understand what you mean. When
I think about photons, there aren't any 'velocity' for $E = 1/2 \cdot m \cdot v^2$,
apart from c of course, to define a kinetic energy. -But if you insist

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about 'kinetic energy', then that it's ok for me. I understand what you mean. But I've learn't (recently), that one should avoid both talking about potential and kinetic energies when working with relativity or 'relativistic particles' like photons.

Kinetic is OK, well defined. Just use $E_k = E - \sqrt{E^2 - p^2 c^2}$.
With potential one should be careful.

OK

I know, that a radiation profile (photons) can express the temperature of its source, but I still don't think, that it will make sense to talk about a temperature for single photons, as it would do when talking about massive particles with $E = E_{kin} = k_B T$.

It doesn't make sense to talk about temperature for single massive particles, either. Temperature is an ensemble property.

I think, that you're right. –Once again I've been thinking about some old book in thermodynamics, where T was a measure for the speed, or kinetic energy, of the individual particles...

Context is important. In the framework of thermodynamics it is always understood that:

- 1) We're talking about an ensemble (in fact, all thermodynamic properties are in the limit of $N \rightarrow \infty$ where N is the number of particles).
- 2) The velocities are relative to the rest frame of the ensemble as a whole.

Absent the second point you would get the "conclusion" that the air in a moving car is at room temperature relative to the car but at much higher temperature relative to the ground:–)

So, the thing you quote, explicitly stated, would go like: "Given some amount of gas at temperature T, the average kinetic energy of a molecule, in the rest frame of the ensemble, is proportional to T".
That's all.

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Using another frame, which is moving compared to the rest frame of the ensemble, would definitively give some strange results. As this can't really be handled, I'm sure, that we will never get a 4-vector for temperature.

If you'll talk with accelerator people you'll find that they often use the term "cooling the beam". And no, this doesn't mean lowering the energy of the beam, just lowering the energy spread, i.e. the dispersion of particle velocities relative to the mean velocity.

May I ask, if you have been working with accelerators?

Maybe it's just a hypothetical question...

It is no more hypothetical than "temperature of gas molecule". There ain't no such thing either. There is "temperature of an ensemble of

gas molecules" and if you've such ensemble and it is at thermal equilibrium, you can, from the temperature, to find the mean velocity, the velocity dispersion etc. for an individual molecule. But this doesn't mean that you can take an individual molecule and talk about its temperature.

No, that's right.

Another example: Sometimes in plasmaphysics for fusion (for example www.ITER.org) people are talking about 'temperature' as a measure of the kinetic energy of (individual) particles. But again, it must be only on ensembles of particles, and not on individual particles. –I think, that there is some confusion about 'con-fusion', as some people are saying, even among the best scientists today... I'm interested in plasma-physics for fusion myself. (Even though, that I'm not actually working with the subject at all.)

So, it is really no different with photons, except that the statistic is different. Given an ensemble of photons in thermal equilibrium with some body (the additional body is necessary in this case, do you know why?), the ensemble has a temperature and from this temperature you can find the average energy of a photon, the energy dispersion, in fact the whole energy distribution. But there is no temperature for an individual photon.

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-I remember our discussion about the 'mass of the photon' (agree that it's zero) some time ago. This time it isn't a posting for April 1st.
(Or do you think so? :-))

Oh no, not at all. First, it is not April and second, I remember the previous exchange.

On Fools Day (April 1st): http://en.wikipedia.org/wiki/April_Fool's_Day
and second:

"It is widely celebrated on the Internet"

Just a stupid joke gives more attention than a serious posting, that's worth to remember...
(But you've right, that I've actually got confused about something in some of my replies.)

Here the joke on mass:

http://groups.google.com/group/sci.physics.relativity/browse_frm/thread/a588600b78c54da4/22535d3586b44eb0?lnk=
(417 replies)

Here a good question on temperature:

http://groups.google.com/group/sci.physics/browse_frm/thread/47626a9b8242be33/02cfe5a053cba16e?lnk=st&q=pecl
(so far 22 replies)

-So the stupid provocation actually got 20 times more replies.

That's worth to think about, I think... (:<)

-Thanks for the reply...

Sure, you're welcome.

Thanks Mati.

pet c

-I post this question, because I think that it could be a good thread.
(good subject or not?), not because I'm in doubt about it, but ok,
always nice to learn something new...

It is a good question, a very good one indeed. Provides an opening for clarification of terms commonly used (and abused). The statement "temperature is just the kinetic energy of particles" is way to often

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used and abused. As it stands, without all the qualifiers mentioned above, it is just plain false.

You know probably better than me here. But it's worth to think about, that temperature is basically a measure of energy, when defined. I agree.

Mati Meron | "When you argue with a fool,
meron@xxxxxxxxxxxxxxxxxxxx | chances are he is doing just the same"

Here a fool only on Fools Day :-)

pet c

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