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Absolute hot

Absolute hot is a theoretical upper limit to the thermodynamic temperature scale, conceived as an opposite to absolute zero.

Contents

Planck temperature

Contemporary models of physical cosmology postulate that the highest possible temperature is the Planck temperature, which has the value $1.416\,785(71) \times 10^{32}$ kelvin, or about 2.55×10^{32} fahrenheit.[1] Above about 10^{32} K, particle energies become so large that gravitational forces between them would become as strong as other fundamental forces according to current theories. There is no existing scientific theory for the behavior of matter at these energies; a quantum theory of gravity would be required.[2] The models of the origin of the universe based on the Big Bang theory assume that the universe passed through this temperature about 10^{-43} s (one Planck time) after the Big Bang as a result of enormous entropy expansion.[1] This Planck temperature may be calculated by using Wien's displacement law. According to that law, temperature is equal to a constant divided by the most probable wave length at that temperature. Assuming that the shortest possible wavelength is Planck length, the temperature is 10^{35} K.

Hagedorn temperature

Another theory of absolute hot is based on the Hagedorn temperature,[3] where the thermal energies of the particles exceed the mass–energy of a hadron particle–antiparticle pair. Instead of temperature rising, at the Hagedorn temperature more and heavier particles are produced by pair production, thus preventing effective further heating, given that only hadrons are produced. However, further heating is possible (with pressure) if the matter undergoes a phase change into a quark–gluon plasma.[4] Therefore, this temperature is more akin to a boiling point rather than an insurmountable barrier. For hadrons, the Hagedorn temperature is 2×10^{12} K, which has been reached and exceeded in LHC and RHIC experiments. However, in string theory, a separate Hagedorn temperature can be defined, where strings similarly provide the extra degrees of freedom. However, it is so high (10^{30} K) that no current or foreseeable experiment can reach it.[5]

Electroweak epoch

In physical cosmology, the electroweak epoch was the period in the evolution of the early universe when the temperature of the universe had fallen enough that the strong force separated from the electroweak interaction, but was high enough for electromagnetism and the weak interaction to remain merged into a single electroweak interaction above the critical temperature for electroweak symmetry breaking (159.5±1.5 GeV in the Standard Model of particle physics). As the universe expanded and cooled, particle interactions were energetic enough to create large numbers of exotic particles, including stable W and Z bosons and Higgs bosons. In the ensuing quark epoch the remaining W and Z bosons decayed, the weak interaction became a short-range force when the Universe was filled with quark–gluon plasma.

See also

- Absolute zero
- Heat
- International Temperature Scale of 1990
- Negative temperature
- Quark–gluon plasma
- Orders of magnitude (temperature)
- Max Planck
- Rolf Hagedorn
- QCD matter

References

1. Tyson, Peter (2007). "Absolute Hot: Is there an opposite to absolute zero?" (https://www.pbs.org/wgbh/nova/zero/hot.html). PBS.org. Archived (https://web.archive.org/web/20090806205915/http://www.pbs.org/wgbh/nova/zero/hot.html) from the original on 6 August 2009. Retrieved 2009-08-11.
2. Hubert Reeves (1991). *The Hour of Our Delight*. W. H. Freeman Company. p. 117. ISBN 978-0-7167-2220-5. "The point at which our physical theories run into most serious difficulties is that where matter reaches a temperature of approximately 10^{32} degrees, also known as Planck's temperature. The extreme density of radiation emitted at this temperature creates a disproportionately intense field of gravity. To go even farther back, a quantum theory of gravity would be necessary, but such a theory has yet to be written."
3. Absolute Hot (https://www.pbs.org/wgbh/nova/physics/absolute-hot.html). NOVA.
4. Satz, Helmut (1981). *Statistical mechanics of quarks and hadrons, International Symposium on Statistical Mechanics of Quarks and Hadrons, 24–31 Aug 1980, Bielefeld, Germany* (https://books.google.com/books?id=OY8uAAAAIAAJ). Amsterdam: North-Holland. ISBN 0-444-86227-7.
5. Atick, Joseph J.; Witten, Edward (1988). "The Hagedorn transition and the number of degrees of freedom of string theory". *Nuclear Physics B*. **310** (2): 291–334. Bibcode:1988NuPhB.310..291A (https://ui.adsabs.harvard.edu/abs/1988NuPhB.310..291A). doi:10.1016/0550-3213(88)90151-4 (https://doi.org/10.1016%2F0550-3213%2888%2990151-4).