A search on the internet renders a whole load of bunkum, bullshit, bollocks (I apologise) regarding any fundamental maximum temperature.

https://futurism.com/science-explained-hottest-possible-temperature

How do we take energy up to infinity? Theoretically, it is possible.

HR: Can anyone deduce that from ascertained physical truths?

the highest possible known temperature is 142 nonillion kelvins (10^{32} K.).

HR: Yeah? Do we really know that? How? Has it been observed?

No heat exchange. No temperature.

HR: Which lucid mind invented that?

https://www.quora.com/Thermodynamics-Is-there-a-maximum-temperature

We know that there can't be anything smaller than planck's length (…)

HR: Yeah? Do we really know that? How? Has it been observed?

BTW: Max Planck was a human being, so please capitalise his name. And it is the Planck length, not Planck's length. The latter would be about 1.75 metres.

The simple answer to the question is: we DO NOT know anything of the above. Max Planck conceived his UNITS as a universal means of communicating with aliens, who are of course unaware of our silly earth-bound units like the metre (it is not a coincidence that Earth's circumference is 40 000 km; it follows from the original definition of the metre: one ten-millionth of the distance from the North Pole to the equator, measured along the meridian through the Pantheon in Paris), the second (originally: one 60^{th} of one 60^{th} of one 24^{th} of the mean solar day) and the kilogram (originally: the mass of a cubic decimetre (a litre) of distilled water at 4 °C).

And then — merely because of their small values — some Homo Non Satis Sapiens (Wotsy Snayme, to be specific) *COINED* the idea that these Planck units would be *minimal* values (or maximal in case of the Planck temperature, just and only because of its absurdly high value) to which Mother Nature should surrender. But this idea was picked from ~~thin air~~ the IGM. It has not been deduced from *any* ascertained truth and therefore it is to be considered flapdoodle, poppycock.

Temperature actually is an emerging quantity, proportional to the (ergodic) mean kinetic energy per molecule in a body's barycentric coordinate system. For a purposeful mean, a large no. of molecules is required during a reasonable time span. In a solid, the molecular motion is vibration and in a fluid, it is the kinetic energy of the stochastic intermolecular motion resulting from collisions. It is definitely not the kinetic energy of their barycentre, i.e. the motion of the body as a whole. I'll call them *stochastic* kinetic energy and *ballistic* kinetic energy. Temperature is equivalent to the mean stochastic kinetic energy.

The Planck temperature would be the highest possible and it would cause thermal radiation with a wavelength equal to the Planck length:

$$T_{\mathrm{P}} = \sqrt{\hbar c^5 / G k_{\mathrm{B}}^2} \approx 1.417 \times 10^{32}\ \mathrm{K}$$

$$l_{\mathrm{P}} = \sqrt{\hbar G / c^3} \approx 1.616 \times 10^{-35}\ \mathrm{m}.$$

I consider the Planck temperature a ridiculously high temperature that is totally unachievable. I have a substitute for it[1], which is not a maximum but looks more like a

[1] see http://henk-reints.nl/astro/HR-Geometry-of-universe-slideshow.pdf (search: "Planck units superfluous")

sort of temperature quantum ($\Delta T_{\text{u}} = 2hH/3k_{\text{B}} = 7.362 \times 10^{-29}$ K). Max Planck did not yet know the Hubble constant, which I obviously incorporated in "my" units[1].

Then there is the Hagedorn temperature[2]: $T_{\text{H}} \triangleq 158$ Mev $\triangleq \sim 1.22 \times 10^{12}$ K.

It is often said this is not to be seen as a fundamental maximum, but as a sort of melting point or so, above which a quark–gluon plasma would come into existence. I think a quark–gluon plasma cannot be a persistent state of a ponderable mass.

The *observed* internal proton pressure is $p_p \approx 10^{35}$ Pa. If the mass of a neutron would be confined to a spherical volume with a diameter equal to its Compton wavelength (the actual diameter of a neutron is slightly greater), its "Compton density" would be:

$$\rho_{\text{C},n} = \frac{m_n}{\frac{4\pi}{3}\left(\frac{\lambda_{\text{C}}}{2}\right)^3} = \frac{3 \cdot 2^3 m_n}{4\pi \frac{h^3}{m_n^3 c^3}} = \frac{6 m_n^4 c^3}{\pi h^3} \approx 1.392 \times 10^{18}\ \text{kg/m}^3$$

the corresponding energy density would be:

$$\eta_{\text{C},n} = \rho_{\text{C},n} c^2 = \frac{6 m_n^4 c^5}{\pi h^3}$$

hence the "Compton pressure":

$$p_{\text{C},n} = \frac{2}{3}\eta_{\text{C},n} = \frac{4 m_n^4 c^5}{\pi h^3} \approx 8.34 \times 10^{34}\ \text{Pa}$$

Look at the aforementioned proton pressure! Do *you* think this is a coincidence? And doesn't it seem *very* plausible that both neutrons and protons can (easily) withstand pressures up to this limit? Newtonian gravitational pressure at the centre of a homogeneous sphere is:

$$p_{\heartsuit} = \frac{2\pi G}{3}\rho^2 r^2 = G \cdot \sqrt[3]{\frac{\pi \rho^4 M^2}{6}}$$

yielding:

$$M = \sqrt{\frac{6 p_{\heartsuit}^3}{\pi \rho^4 G^3}}$$

as the minimal mass required to achieve a given central pressure at a given density.
What we just found for the neutron renders:

$$M = \sqrt{\frac{6\left(\frac{4 m_n^4 c^5}{\pi h^3}\right)^3}{\pi\left(\frac{6 m_n^4 c^3}{\pi h^3}\right)^4 G^3}} = \sqrt{\frac{6 \cdot 4^3 m_n^{12} c^{15} (\pi h^3)^4}{\pi \cdot 6^4 m_n^{16} c^{12} (\pi h^3)^3 G^3}} = \sqrt{\frac{8 c^3 h^3}{27 m_n^4 G^3}} \approx 3.15 \times 10^{31}\ \text{kg} \approx 15.84 M_{\odot}$$

At least roughly 16 solar masses of neutronium at this "Compton density" would be required to obtain a Newtonian central gravitational pressure able to crush protons/neutrons!

From Schwarzschild's interior solution follows that the inside of a black hole has no compressive pressure at all[3], no matter its actual size. Instead, it has a homogeneous *expansive* pressure of ρc^2, i.e. its energy density. **YES!** And the homogeneity of this pressure indicates there is NO gravitation inside a BH!

[2] see https://cerncourier.com/a/the-tale-of-the-hagedorn-temperature/
[3] see http://henk-reints.nl/astro/HR-Schwarzschild-interior.pdf

I challenge YOU to PROVE (i.e. ***deduce*** from demonstrable ***facts***) that a greater density than the neutron Compton density is possible at all.

If a body's material radius were merely 1% above the Schwarzschild radius, then $p_{@r_\mathrm{S}} \approx 0.567\rho c^2 < p_\mathrm{C} = \frac{2}{3}\rho_\mathrm{C} c^2$, i.e. still below the material's Compton pressure. The thing would be near the end of a collapse into a BH, since it becomes unstable if $r_\mathrm{m} < \frac{9}{8} r_\mathrm{S}$.

We could assign a (pseudo) temperature to a neutron:

$$T = 2E_n/3k_\mathrm{B} = 2m_n c^2/3k_\mathrm{B} \approx 7.27 \times 10^{12}\ \mathrm{K} \approx 5.95 T_\mathrm{H}$$

A body in free fall from infity would at the Schwarzschild radius of a BH have a kinetic energy of its mass times the depth of the potential well. This potential equals $-c^2/2$, yielding a kinetic energy of $mc^2/2$ which is half its rest energy. For each impacting baryon (assuming a larger body fully disintegrates), this would turn into thermal energy, yielding half the just mentioned neutron temperature. This is not really far above the Hagedorn temperature. How do you think to achieve a higher temperature than this, without already having something even hotter (don't count on Miss Universe...)?

Altogether, this would mean that the conditions required for a ponderable persistent quark–gluon plasma cannot ever be achieved.

I insist the Hagedorn temperature *is* some sort of fundamental maximum. It roughly equals the temperature where the stochastic kinetic energy equals the $E = mc^2$ of pions (the lightest hadrons). It implies pair production starts to take place, becoming more and more abundant as energy is added to the system. Pions will be created. They have a very short decay time, but the energy remains, so new pions WILL be produced.

Addition of more energy no longer significantly increases the energy per molecule. Instead, it increass their amount, thus keeping the mean energy per molecule more or less the same. That means the temperature no longer rises. The body (which at this temperature of roughly a terakelvin must be a fully ionised plasma) no longer has the slightest resemblance to an ideal gas, which by definition is a collection of non-interacting point-like molecules that are moving freely (according to Newton's 1st law), but frequently undergoing fully elastic collisions (where Newton's 3rd and 2nd laws apply). It means the ideal gas law ($T = PV/Nk_\mathrm{B}$) no longer applies at all at or above the Hagedorn temperature. Addition of energy increases PV & N in the same way, keeping their ratio more or less unmodified, so there will be no essential rise in temperature.

I do not see the Hagedorn temperature as a sharp temperature limit, but as a vague and swampy unsurpassable temperature range where nature strands. A ponderable persistent body cannot become significantly hotter.

Physics is not about what you can think of, but what you can deduce
from propositions collected by induction from observed phenomena.

