

The cold outdoors

Things in outer space cool to nearly absolute zero within seconds, says S. Ananthanarayanan

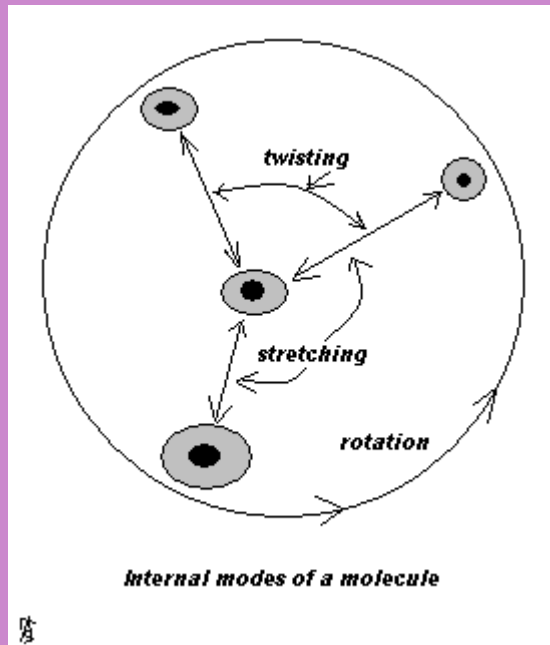
Warm objects cool by two mechanisms – convection, which is when the surrounding medium, like air or water carries away the heat, or by radiation, which is when the warm body gives off energy in the form of electromagnetic radiation, mostly in the infra red region.

In outer space, there is no air or water surrounding an object and cooling is all by radiation.

Cooling by radiation

The heat content of an object is nothing but the incessant motion of its constituent parts. In a gas or a liquid, the molecules of the gas are in constant, zigzag motion, like projectiles. But in a solid, the molecules are bound to each other not as free as in a fluid. Their motion is hence limited to vibration and twisting around, rather like pendulums or watch-springs.

Now, the extent of these motions increases or decreases not ‘continuously’, or smoothly, but only in ‘steps’, for every ‘quantum’ of energy that is gained or lost.



And while a molecule or atom that is in a higher energy state usually emits a photon of light and drops to a lower state within a very short time, other, similarly emitted photons may also strike the system and get ‘absorbed’ for the system to be ‘kicked’ back into the higher state.

And this is the way a very hot object gives off high-energy photons faster than it receives energy and it cools fast. But a body already quite cool may gain more energy than it emits and warm up! This radiation, corresponding to the modest energy levels of motion of molecules and atoms is in the infrared region.

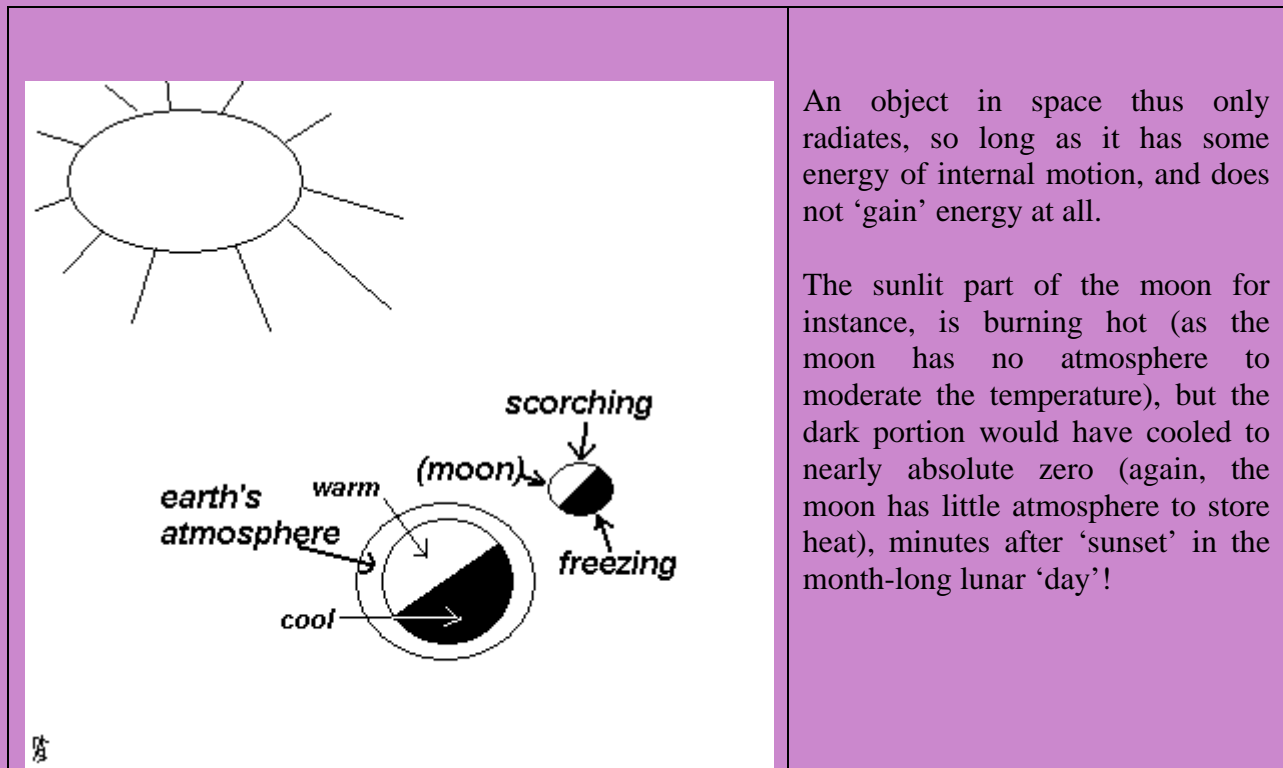
Absolute zero

Temperature thus corresponds to motion and in motion there is also the state of rest. This means there is a state when a thing can get no cooler. This temperature, in fact, which corresponds to

the lowest motion state of molecules and atoms, is about 273°C below the freezing point of water. We can imagine that as everything else would be warmer than an object at such a low temperature, it is very difficult to cool anything down this far, and again, to keep it from warming up in a jiffy!

Its cold out there!

And rightly, it's a difficult thing to get things so cool. But in outer space, except when bathed in the 'sunlight' of a nearby star, there is only a thin presence of 'dust' of clumps of molecules and no substantial object sometimes for millions of kilometers.



An object in space thus only radiates, so long as it has some energy of internal motion, and does not 'gain' energy at all.

The sunlit part of the moon for instance, is burning hot (as the moon has no atmosphere to moderate the temperature), but the dark portion would have cooled to nearly absolute zero (again, the moon has little atmosphere to store heat), minutes after 'sunset' in the month-long lunar 'day'!