MY EMAIL REQUEST

Your article has left me with an important, unanswered question:

According to the law of conservation of energy, since energy can be neither created nor destroyed ... where is all the energy going?

REPLY FROM LUKE DAVIES

The total amount of energy in the Universe is conserved, it is just changed into different forms. The article in question was concerning the energy output from stars in galaxies, and how this is changing with time. All of the energy in the Universe was produced in the Big Bang, and sometime after, a lot of this was stored up in mass (mostly in the form of Hydrogen), and the rest of the energy eventually streamed through the Universe as the Cosmic Microwave Background radiation.

Over the age of the Universe, a large fraction of this mass is turned back into other forms of energy (light and heat mostly). Stars are the factories that do this conversion. The hydrogen formed soon after the big bang collapses in on itself under gravity until the density is so high that nuclear fusion begins - and a star is born. This fusion process takes the energy that is stored up in mass and turns it into light, heat and new heavier particles (like carbon, oxygen, and nitrogen). This light and heat produced is then emitted by stars and we see it. This is essentially what astronomers measure; we see the glow from billions of nuclear reactors. This process continues in more and more stars as galaxies eventually form and evolve. What this study is measuring is the rate at which the stars are converting the energy stored up in galaxies back into light, and we find that this is decreasing at the current time.

We know that this rate increases for about the first 3.5 billion years of the Universe and then slowly starts to decline. This is because less stars are forming in the Universe and less mass is converted into light and heat. As this continues less and less light and heat will be produced. Eventually (in about 100 billion years) no new stars will be formed, the stars that already exist will cool and stop their fusion processes, cool more, and no new light and heat will be produced in the Universe. The light that has already been produced will stream out in the Universe getting more and more redshifted (just like the CMB) and the heat from all stars will slowly disperse and come into equilibrium (like the 3rd law of thermodynamics) until the whole Universe is a single cold temperature and a very dark place.

At this point some of the energy will be in light in the Universe, but at very, very long wavelengths, some will be in heat but it will be uniform across the whole Universe, and some will still be stored in mass in the cold dark remnants of stars and galaxies. So it's not that the energy is destroyed or leaves the Universe it is just ends up in different forms.

(I also received a similar reply from Simon Driver)