About nothing

Tapping, Ken

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/23004086
Skygazing: Astronomy through the seasons, 2018-09-18

ABOUT NOTHING

Ken Tapping, 18th September, 2018

In the 17th century Evangelista Torricelli invented the barometer. In the same century, Blaise Pascal carried one of Torricelli's barometers to the tops of high buildings and mountains, and found that the air pressure falls off with increasing height. Since those barometers consisted of vertical metre-long tubes filled with mercury, and had to be kept vertical, this was no trivial matter. Barometers were taken up in balloons, affirming that as the altitude increased, the air pressure continued to drop. Above about 5 km the air pressure falls to a point where there is not enough oxygen to sustain anyone not extra healthy and adapted to high altitudes. Modern airlines fly at heights of around 12km; the aircraft have to be pressurized.

Air pressure is the force we feel from being hit by a huge number of the molecules and atoms making up the air. The more of them bouncing off us per second, or the faster they are moving, the more pressure we feel. Above 100 km or so, the number of atoms per cubic centimetre is very low; as we continue to get higher, the atmosphere eventually merges with space, where there are just a few atoms per cubic centimetre. This is a far better vacuum than any we can achieve in the laboratory. We could consider space as being essentially "nothing", and we would be wrong. Although there is almost everywhere, even in the denser cosmic clouds, what we would call a very good vacuum, containing almost nothing per cubic metre, there are other things going on, in addition to dark matter and dark energy.

Isaac Newton saw space as just a huge empty volume in which objects and radiation moved around and interacted. It is easy to imagine the Big Bang – the beginning of our universe - almost 14 billion years ago, as a massive explosion, with things blasting off in all directions into the empty space Newton imagined. The expanding universe would be just the cloud of debris getting bigger and bigger as it moves further out into space, forming galaxies, stars and planets as it goes. This is the easy picture, and it does not work. One interesting aspect of this picture is that the expansion of the universe appears to us exactly the same in every direction we look. That would mean we live at the centre of the universe! Once we believed we were. Now we know we are just one very small part of it.

The picture we get from the work of Albert Einstein and others fits better, and is far more intriguing. Imagine a bunch of ants running around on the surface of an expanding balloon. Each ant would see the same thing: all the other ants getting further and further away, with the more distant ants receding faster than the nearby ones. The ants are not moving with respect to the balloon; they are being carried along by the balloon's expansion. That balloon represents a two-dimensional universe expanding in a third dimension. Our universe seems to be a three-dimensional universe expanding in a fourth dimension. However, what plays the role of the rubber surface of that balloon, which is carrying all those ants with it? Einstein showed that space is not a "nothing"; it is part of a multidimensional "something" called the fabric of space-time. In our case the ants are the galaxies we see around us, being carried further and further apart as our space-time "balloon" expands. This leads to another interesting thing. At the moment of the Big Bang, everything, including space-time, came into existence. So far we have not managed to come up with any firm scientific idea about what existed before that moment.

At 18:54 PDT, or 21:54 EDT, on the 22nd, the Sun will cross the equator, heading south, marking the Autumn Equinox. On that day the Sun will be above the horizon for as long as it is below.

During the evening Mars, the red planet, is conspicuous low in the southeast. Saturn is low the south and Jupiter very low in the southwest. The Moon will be Full on the 24th.

Ken Tapping is an astronomer with the National Research Council's Dominion Radio Astrophysical Observatory, Penticton, BC, V2A 6J9.

Tel (250) 497-2300, Fax (250) 497-2355

E-mail: ken.tapping@nrc-cnrc.gc.ca