Discovery of abundant oxygen in a comet by Rosetta

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The renowned scientific journal Nature published a perplexing discovery on Thursday October 29th: the European Space Agency's Rosetta spacecraft has discovered – for the first time ever – the presence of oxygen gas O2 in the atmosphere of comet 67P/Churyumov-Gerasimenko. Moreover, oxygen turns out to be a major component, constituting up to 10% of the comet atmosphere.

This discovery is unexpected. In our daily lives, we experience how oxygen gas has the tendency to oxidize materials, that is: the oxygen atoms try to bond to other atoms, since this is a process that releases energy. Examples include the burning of fossil fuels (carbon) with air (containing O2) which leads to CO2, and the oxidation of iron leading to "rust". One would therefore expect that, if there ever was O2 on a comet, it would have chemically reacted away – there would have been time enough for this, since a comet is more than 4 billion years old, as old as our solar system. How is it then possible to find abundant oxygen gas in a comet?

The paper "Abundant molecular oxygen in the coma of comet 67P/Churyumov–Gerasimenko" by A. Bieler et al. reports on this discovery and discusses possible explanations.

The simplest explanation is to assume that the oxygen was there from the moment the comet was formed. Since comets stay in the very cold outer regions of the solar system, any chemical reactions would be extremely slow, so that it could be preserved up to now. But this raises new questions : was the O2 produced while the planets formed, or was it already present in the gas and dust cloud from which the Sun and the planets condensed? Astronomers do not observe oxygen in typical proto-planetary gas and dust clouds.

There is one alternative explanation. O2 could be created in the ices in a comet during its 4 billion year stay in the outer solar system by bombardment with "cosmic rays". These are very energetic atoms that zip through the galaxy. There are not many of them, but because of their high energy and because 4 billion years is a very long time, it seems that enough O2 can be produced. The scientists, however, are very prudent in drawing conclusions: there is a lot of uncertainty about the detailed low-temperature chemistry, and the flux of cosmic rays over the past 4 billion years is not well known, which makes it hard to prove or disprove this alternative explanation.

In any case, the discovery of abundant oxygen gas completely overthrows a lot of earlier modelling work concerning the composition of comet atmospheres. It raises again the question of the contribution of comets to the Earth's composition – Rosetta has now discovered both nitrogen and oxygen gas in the comet atmosphere, and these are the main components of the air that we breathe – but there does not seem to be a direct relation.

This discovery was made possible through the use of the DFMS mass spectrometer onboard Rosetta. The detector assembly of this mass spectrometer is a Belgian contribution (Belgian Institute for Space Aeronomy, IMEC Leuven, OIP Oudenaarde). Scientists at the Belgian Institute for Space Aeronomy are co-authors of this research published in Nature and are supported by the Belgian federal Science Policy Office.

http://www.aeronomie.be/en/news-press/2015-10-29-oxygen-comet.htm

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