Some Background on Comets

What do comets look like?

Comets are the oddballs of the solar system. They do not look like anything else, each one appears different, and they can be quite unpredictable (they have been likened to cats!). They are different sizes, brightness, and colour, and some have spectacular tails.

Comets in history

The name 'comet' comes from the Greek word **kometes** meaning **hair.** Comets were described as hairy stars.

Their appearance was so unpredictable, and they were sometimes so bright, that some people were afraid of them. They thought they brought disaster. This meant that they were closely studied to try to predict when they would appear, so rulers could try to avoid disasters. These observations, over thousands of years, have proved very useful in identifying returning comets.

The Chinese observed and recorded their observations from as long ago as 1500 BC. The Mawangdui silk, shows the different shapes of comets observed, and also lists disasters around the time of comets appearing.

The 1066 appearance (known as an apparition) of Comet Halley was shown in the Bayeux Tapestry which shows the Battle of Hastings. That certainly was a year of disaster for King Harold – he was shot with an arrow and died!

Can you spot the comet in the picture?

In the past, some people thought things in the sky did not change. This was because most of the things they could see when they looked up, stars, seem to stay in their same patterns. Although the moon and the planets changed positions, these changes were regular and people could predict them. Other people thought there were things that did change, and comets were things that certainly did appear to change. (Once telescopes were invented astronomers found that many things did indeed change – but we just had not been able to see them!)

Over the years there had been a lot of discussion about what comets were, where in the sky they were, and whether their appearance could be predicted. Some astronomers made predictions. In 1705 an astronomer called Edmond Halley worked out that we may see the same comet many times, as they too might orbit around the Sun like the Earth does. He looked at when comets had been observed and thought he saw a pattern. He predicted the return of a particular comet. His analysis of older records of comets had shown that there was a pattern of around 76 years between similar bright comets. Unfortunately he did not live long enough to be proved correct and see the comet that now bears his name, Halley's Comet, return in 1758. Halley's careful observations and analysis, along with others such as Tycho Brahe, proved that comets were outside our atmosphere and travelled great distances in their orbit of the Sun.

Are comets important now?

You might wonder why we still study comets. The answer is that they contain clues to answer big questions like:

How did the solar system form?

What were the original ingredients?

How did water and life get to Earth?

Did water and life get to other planets too?

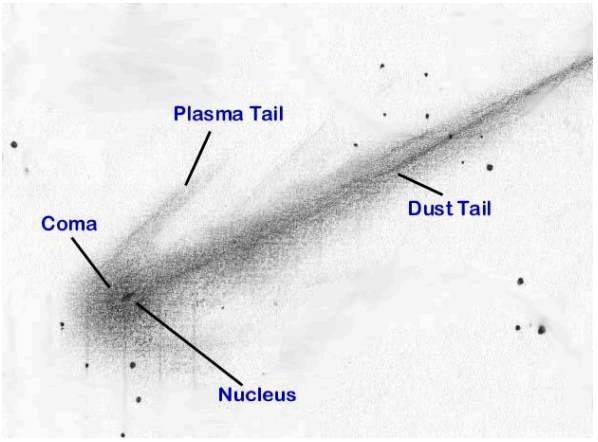
Also, tracking comets is very important to see if they might hit the Earth! A comet hitting the Earth is a possible cause for the extinction event that killed the dinosaurs 65 million years ago. Any future impact could have serious consequences for the future of life on Earth. We would like as much warning time as possible so that we can try to do something about it.

What is the make-up of a Comet?

There are three basic parts to a comet:

a. the nucleus
b. the coma
c. the tails

Comet Hale-Bopp
photo by Elizabeth Warner



Drawing by W.D. Ferris

Comet Nucleus

The innermost region of the comet is known as the nucleus. It is very hard to directly observe as it is very dark and does not reflect much light. When the early space missions to a comet made close-up observations of Comet Halley they found it was a solid structure (rather than just a collection of particles) and was as dark as printer toner. Generally comets are quite small – less than 10km across. More recently, the Rosetta Mission to comet 67P orbited the comet nucleus for over two years, taking lots of pictures and making many measurements. The surface is harder than expected – which is why the lander Philae bounced on landing and then could not drill into the surface.

The scientists think the nucleus has a hard crust of dust, with some smaller loose particles. Below the surface is a porous (many holes) mix of dust and different types of ices. It is like a snowball made of soft fluffy snow, but mixed with a lot of dust. There are cavities below the surface, and holes, dents, cracks and cliffs on the surface. Perhaps the most surprising thing about 67P though was its shape – like a duck! - leading to a theory that the comet was once two objects which slowly collided and stuck together.

Like Earth, a comet nucleus rotates as it travels through space. Scientists try to find out the rotation period (a comet 'day') and the axis of rotation. This is important as it affects which parts of the comet get most sunlight. That influences how active the comet becomes and how much gas and dust it releases into space.

When comets make their first pass close to the Sun they release a lot of dust and gas into space. When a comet has been close to the Sun many times it develops a harder crust which means the sunlight cannot so easily get to the ices beneath, and so it gives off less gas and dust (known as being less 'active').

Comet Coma

The coma is a huge cloud of dust and gas surrounding the nucleus. Most of the gas comes from ices which have sublimated from the nucleus. Sublimated means having gone from the solid state (like ice) to the gas

state (like steam) skipping the liquid (water) state. As it is difficult to test a comet nucleus directly, scientists have to analyse the coma instead and try to work out the make-up of the nucleus from the gas and dust emitted.

(If you would like to find out more about the different chemicals that Rosetta has detected on Comet 67P have a look here (it is fun too). Cometary Zoo - http://blogs.esa.int/rosetta/2016/09/29/the-cometary-zoo/)

While the nucleus of a comet may only be a few kilometres in diameter, the coma can extend for hundreds of thousands of kilometres. The coma changes in both brightness and shape through a comet's orbit. Generally the coma is smaller and less bright when the comet is a long way from the sun. As it gets close to the sun and more gas and dust is released the coma gets brighter and bigger as there is more material to reflect sunlight. This is not necessarily a smooth process though. There may be outbursts of material from cracks and features on the surface (even ice -volcanoes) which cause a big jump in brightness and size. Large outbursts can be detected from Earth – we want observers to look for these and alert us. These outbursts can form jets and arcs and make the coma very asymmetrical (that means it looks different on different sides). This can allow us to detect how the comet is rotating and spinning.

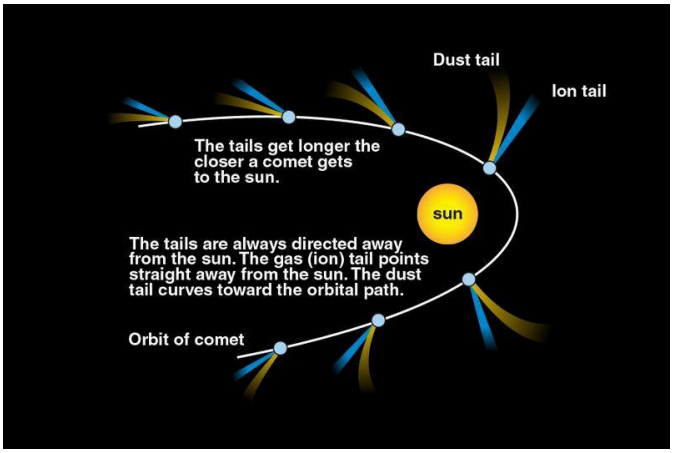
This composite photo shows the fascinating evolution of a 29P flare-up from June 16, 2013 (lower left) to July 28th. The comet's coma often displays a characteristic horseshoe or spiral shape early on as we view the outburst side-on across one hemisphere only.
Damian Peach

By measuring the colour of the coma we can detect dust (using a red filter to see just the red parts caused by dust) and gas (using a green or blue filter to see the colour of gases) features. So analysing the coma is very useful.

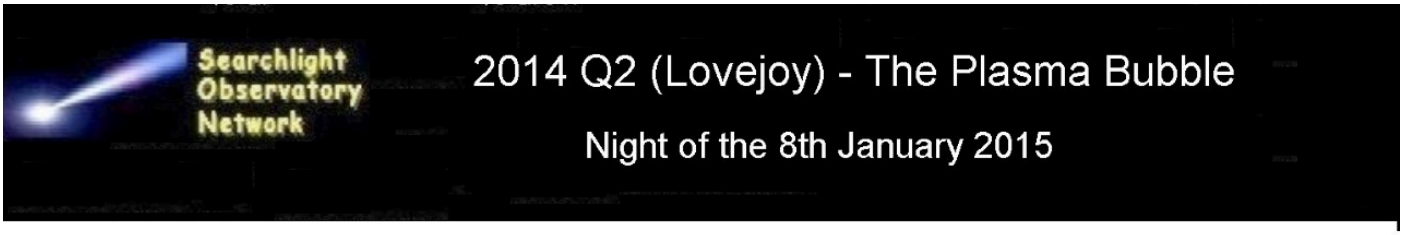
Comet Tails

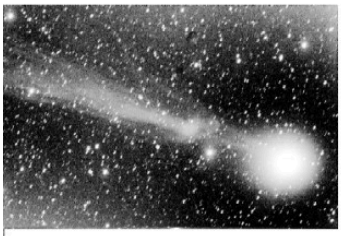
A comet, while close to the sun, usually has two tails. The ion tail is made mostly of gas and always points directly away from the sun. The other tail is made of dust and curves, it points away from the sun too but curves towards the path the comet takes. . The tails can look weird since sometimes the tail will be in front of the comet as the comet heads away from the sun along its orbit.

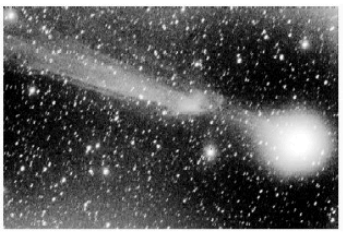
If a comet has an orbit that crosses the Earth's orbit, we might pass through that trail and have a meteor shower.



Studying comet tails tells us not only things about the comet but also about the solar wind. This is material which comes from the Sun and travels at high speed - it ranges from 300 to 700 km per second! The Solar wind affects the shape of the coma, but it's most dramatic effect can be seen when it meets a comet's tail.




2015-01-08T18:48:40
The bubble is 37 arc minutes from the coma centre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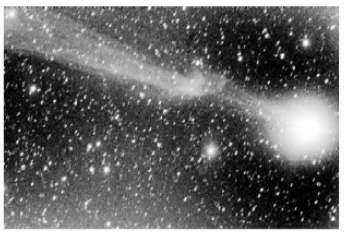
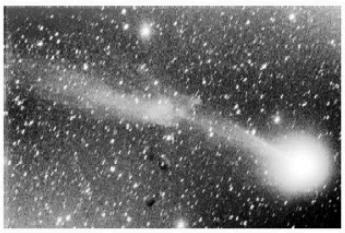
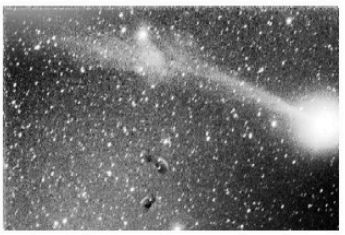
The Bubble is 41.5 arc minutes from the coma centre


2015-01-08T20:34:24
The Bubble is 44 arc minutes from the coma centre


2015-01-08T21:42:46
The Bubble is 48.5 arc minutes from the coma centre


2015-01-08T22:63:41
The Bubble is 55 arc minutes from the coma centre

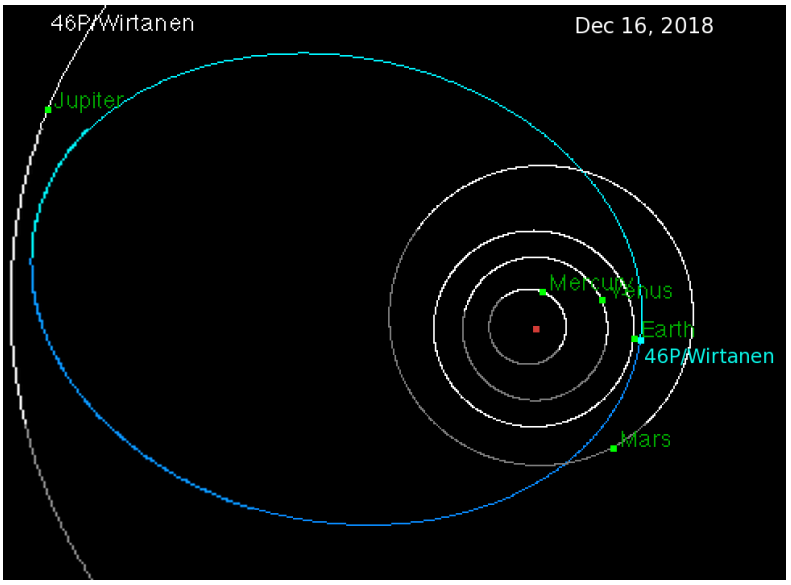

2015-01-08T23:51:59
The Bubble is 59.5 arc minutes from the coma centre


2015-01-09T01:10:57
The Bubble is 66 arc minutes from the coma centre

You can see in the pictures above the changing shape of the tail as material from the Sun passes through it. This change happens very quickly, over just a few hours. This one was quite special, and Tony Angel (who is one of our project advisers) and Caisey Harlingten were very excited to get these pictures from their observatory in Spain.

Comet Orbits

Comets, like the planets, orbit around the sun. But the orbits of comets tend to be much more elliptical (oval - like a squashed circle). Comets (like other solar system bodies) travel faster when closer to the Sun than when further away from the Sun.



This is the orbit of Comet 46P

An interactive version of the orbit can be found here
https://ssd.jpl.nasa.gov/sbdb.cgi?sstr=46p;old=0;orb=1;cov=0;log=0;cad=0#orb

Another good site is https://theskylive.com/3dsolarsystem

On this site you will be able to see where the comet is in the solar system at any time, run its orbit at many times actual speed, and also view it from various angles. You can easily also choose a different comet – Comet Halley (also known as Comet 1P), would be a good one - to compare orbits.

(Click the ANIMATE box to watch the comets and planets move in their orbit)

Different comets have different orbits as shown in this animation.

https://www.youtube.com/watch?v=7l16fVKKURs

Some comets have a relatively small orbit and so pass around the Sun quite quickly – like 46P which takes 5.44 years to complete an orbit (the comet's year). Others have much bigger orbits and so take much longer to complete an orbit – Halley's comet takes 76 years.

Unlike planets, comet orbits may change. This can be due to them coming under the power of the gravity of a large planet (particularly Jupiter). Also, jets from a comet can alter its course slightly (think about how a rocket's direction is changed if the engine is fired).

As comets pass close to the Sun they lose gas and dust and so become a bit smaller each orbit. Eventually they will lose the materials which can escape and so become non-active. Then they cannot be seen any more. Some asteroids may actually be dead comets.

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