ORBYTS 2017/2018 at Highams Park

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1 ORBYTS, the Twinkle Space Mission and ExoMol

- An **exoplanet** is any planet not in our solar system; it orbits a star other than our own. There have been **almost 3500** exoplanets detected to date (as of September 2017). All those detected are in our Milky Way galaxy. There is no reason to think they do not exist in other galaxies but they are too far away to detect.
- **Twinkle** (http://www.twinkle-spacemission.co.uk/) is a mission, set to launch into earth-orbit in 2020, primarily led by researchers at UCL, London.
- The satellite (Figure 4) will analyse light from stars in our universe (which are already known to have a planet in orbit), in order to investigate what molecules are in the atmospheres of the target planets (these are called exoplanets; any planets orbiting a star other than our own).
- We are just entering the scientific era where exoplanet atmospheres will be studied extensively, with other big missions such as JWST (James Webb Space Telescope https://www.jwst.nasa.gov/) set to launch within the next couple of years.
- If the planet happens to pass infront of it's host star, from the point of view of the earth, then we can tell there is a planet from the dip in light as the planet is blocking it (see https://exoplanets.nasa.gov/). This is called the **transit method** - see Figure 1.

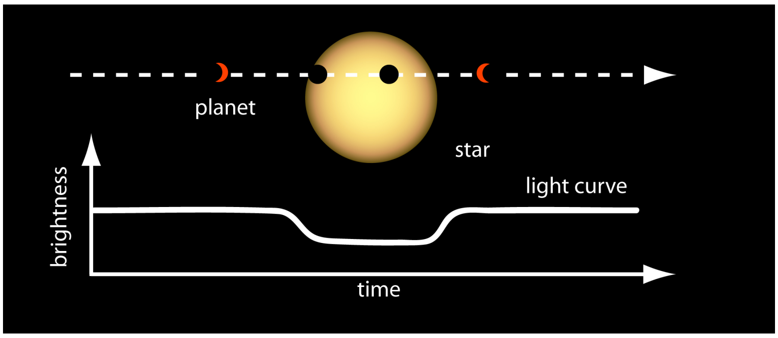

Figure 1: An illustration of the transit method, where the brightness of a star dips as a planet passes infront.

- The region of importance for astronomical observations using Twinkle is in the IR (infra-red) - see Figure 2.

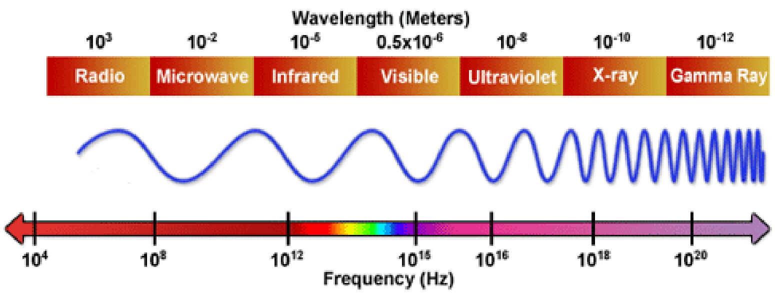

Figure 2: EM spectrum showing the IR region

- Each molecule will have so-called energy levels. These are a defined set of energies, dictated by the laws of quantum mechanics, of which a molecule can hold. The set of energies that are allowed is completely unique for each molecule. A molecule can have electronic, vibrational and rotational energy levels.
- When a photon of light passes through a molecule, if it holds one of the unique amounts of energy related to the particular molecule, E, or frequency, ν, (which are directly proportional to one another: $E = h\nu$, where h is Planck's constant ($6.63 \times 10{-}34$ Js). Note: the terms 'energy' and 'frequency' are sometimes used interchangeably) the molecule will absorb the photon and gain some internal energy.
- Then energy states in order of highest to lowest:
  1. Electronic (energy of the electrons)
  2. Vibrational (energy of the molecule vibrating as a whole, stretching and bending)
  3. Rotational (energy of the molecule rotating as a whole)
- This gained energy will either cause the molecule to go up an electronic, vibrational or rotational energy level. There are millions of different levels for each molecule, with the exact amounts completely unique for each different molecule.
- For diatomics (molecules with only 2 atoms), electronic, vibrational and rotational transitions need to be considered, but for polyatomics (molecules with more than two atoms), only vibrations and rotations are important in the IR region of the electromagnetic (EM) spectrum.
- **ExoMol** (www.exomol.com), a group at UCL closely linked to the Twinkle space mission, perform theoretical calculations using quantum mechanics in order to work out what the light will look like depending on which molecule is in the atmosphere. Figure 3 shows the spectra of some different molecules, in the wavelength region of the Twinkle Space Mission.

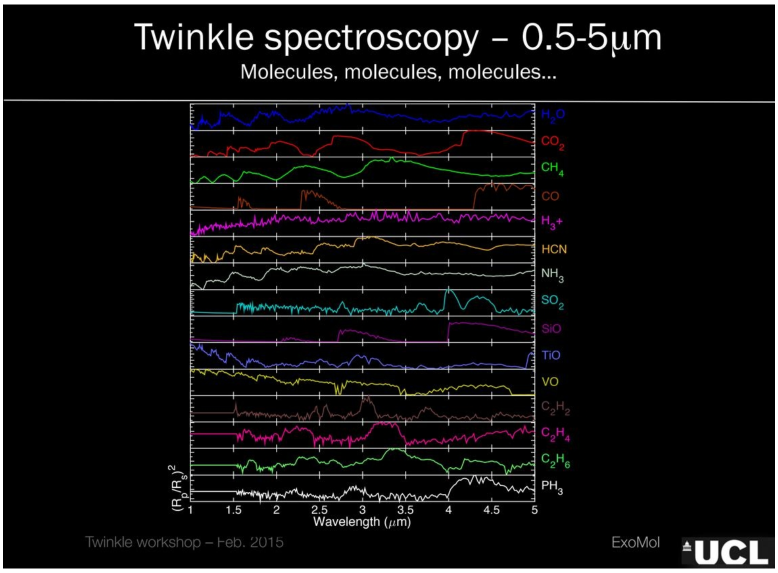

Figure 3: The spectra of different molecules, in the wavelength region of the Twinkle Space Mission.

- The ExoMol project builds a database of molecules, with each spectra or line-list acting like a unique barcode or signature for that molecule. This is essential for the astronomers who are observing these distance star-planet systems to be able to investigate their atmospheres.
- Figure 6 [1] gives an observed spectra from a planet, HD189733b (known as a hot Jupiter), orbiting a binary star system which is 63 light years away (for reference, our sun is 8 light-minutes away, that is it takes light 8 minutes to reach the earth). The black triangles give the observational data, collected from the Hubble space telescope. The blue spectra is theoretical spectra of water on its own (based on theoretical calculations by the ExoMol group [2]), and the orange is methane [3] and water combined together (see Figure 2 of [4, 1]).

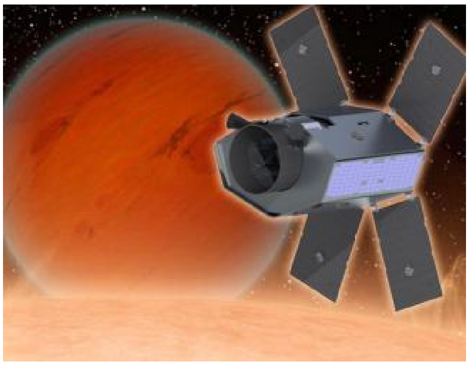

Figure 4: Illustration of the Twinkle Space satellite

Figure 5: The ExoMol group at UCL

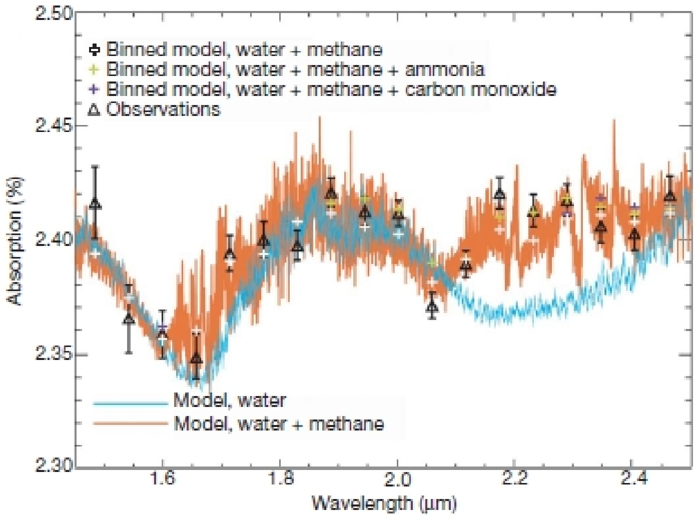

Figure 6: Observed spectra from a planet, HD189733b (known as a hot Jupiter) with spectral data fitted to it. See [1] for original.

- As part of the Twinkle Space Mission's educational programme, **EduTwinkle**, students between the ages of 17 and 18 have been performing original research associated with the exploration of space since January 2016. This programme is called **ORBYTS (Original Research by Young Twinkle Students)** (www.orbyts.co.uk). Figure 7 is one of the 2016/2017 ORBYTS groups from Highams Park meeting Helen Sharman, the first British astronaut.

Figure 7: 2016/2017 ORBYTS students from Highams Park School, with first British astronaut Helen Sharman. Professor Giovanna Tinetti, Science lead for the Twinkle Space Mission, is also present.

- Clara-Sousa Silva (front row, right of Figure 5) founded the ORBYTS project in 2016, originally with tutors (PhD students and Post-docs) from ExoMol and now it has expanded to include people from other research groups at UCL and other universities. This research aims to meet a standard for publication in peer-reviewed journals.
- At present the research of two ORBYTS teams have been published, one in the Astrophysical Journal Supplement Series [5] and another in JQSRT [6].
- More papers from 2016/2017 are due to be published soon. We aim to publish more as a result of the 2017/2018 ORBYTS projects.

2 Session 1 - Solar System Objects and Software for Writing Scientific Papers

1. Register for www.sharelatex.com and create a new blank document
2. Add your name and the title "The Atmosphere of (your given solar system object)"
3. Research (using google) what molecules are in the atmosphere of your planet or moon, in order of the largest proportion. Add these to a list in latex
4. Add an image/images of your object
5. Add a two column table with statistics for: mass, radius, distance from the sun, temperature, thickness of the atmosphere, pressure
6. Use google scholar to find some scientific papers on the atmosphere of your planet/moon and add them as references in your Latex document
7. Click the share button in the top right and share with orbyts2017@gmail.com

References

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