EXOPLANET ATMOSPHERES

Students use diffraction gratings to observe the spectra from different sources, and deduce how we can work out which chemicals are present in an exoplanet's atmosphere.

Apparatus and Materials

(per group of 2 to 4 students)

- Access to a variety of light sources (filament lamp, fluorescent lamp, sodium lamp, LED torch)
- Bunsen flame
- Diffraction grating or spectroscope
- Sodium chloride – a few grains

Each student will also require a photocopy of the instructions and worksheet (pages 12 and 13 respectively).

Health & Safety and Technical Notes

Refer to CLEAPSS Laboratory Handbook 9.10.2 for Bunsen burner precautions. Warn students not to stare directly into the lamp.

Learning objectives

After completing this activity, students should be able to:

- describe how a spectrum of light can be produced using a spectroscope/diffraction grating.
- understand that a spectrum shows the different wavelengths present in the light from a source.
- understand that a spectrum can tell us about the elements present in the light source.
- describe and explain how an absorption spectrum can tell us about the elements present in an exoplanet's atmosphere.

Introducing the activity

Introduce the idea that, to find out more about distant stars and exoplanets, astronomers analyse their light. Show how to observe a spectrum by looking through a diffraction grating/spectroscope.

The practical activity

It is important that students can observe a number of light sources. You may wish to place several around the room and allow students to move around from one to another, recording their observations as they go.

Alternatively, you could set up each source in turn at the front of the room so that all students can see the same source and spectrum at the same time. This will allow you to discuss what they are observing so that you can be sure that all students have seen a number of different spectra.

Some students may find it difficult to observe a spectrum. If you have provided handheld spectroscopes show them how they can change the width of the slit to let more or less light in. If they are using unmounted diffraction gratings they should hold the diffraction grating close to one eye and look directly at the source. Then, by looking to one side, they should see a spectrum. It may help to use card or paper to cover most of the grating, leaving a small slit uncovered.

You may have access to a set of discharge tubes each of which contains a different gas at low pressure. By connecting each in turn to a power source you can show the different colours produced, and their spectra.

To produce a sodium flame, either sprinkle a few grains of salt in the flame or use a metal rod dipped in concentrated salt solution.

About diffraction gratings

Traditionally, prisms are used to show spectra. These do not work well for observing different sources, whereas diffraction gratings can be relied on to produce good spectra.

It is not necessary to discuss how diffraction gratings work. Treat them as a useful piece of equipment for splitting light into its component wavelengths or colours.

About the demonstration

This introduces the idea of absorption of light. Students will be familiar with the idea of how shadows are formed, but they may not think of this as the absorption of light. They may never have thought about whether a gas can absorb light.

You can see a video version of the demonstration at **www.iop.org/exoplanets**

You need to be able to shine a bright white light at a Bunsen burner so that a shadow is cast on a screen or wall. You will also need a sodium lamp to use in place of the white light.

The student worksheet shows the stages in building up this demonstration (see Figure 3a for expected responses). You can discuss each step as you go along, or you can demonstrate each step and leave students to complete the sheet, following up by asking students to present their ideas.

About the atmospheres of exoplanets

Explain that the sodium flame has a shadow in sodium light because the light from the sodium lamp is absorbed by the sodium atoms in the flame. So the shadow of the flame shows that it contains sodium.

Go on to explain that, when an exoplanet passes in front of its star, some of the starlight is absorbed by the exoplanet's atmosphere. Astronomers look for changes in the spectrum of the light from a star. If they observe that some wavelengths become dimmer as the exoplanet transits across in front of it, they can deduce which elements and compounds are present in the planet's atmosphere.

This is similar to the observation that the Sun's spectrum has certain wavelengths 'missing'. These appear as dark absorption bands in the Sun's spectrum and allow us to identify the elements present in the Sun's atmosphere.

Taking it further

Students can find out about the spectra of stars with exoplanets and how these indicate the substances present in the exoplanets' atmospheres. They should look for examples of exoplanets with oxygen and water in their atmospheres as these may be home to life similar to that found on Earth.

Figure 3a

Student worksheet responses

Demonstration	Observation	Explanation
White light is shone at a Bunsen flame.	*There is no shadow of the flame.*	*The flame transmits white light.*
Sodium chloride is added to the flame.	*There is no shadow of the flame.*	*The sodium flame transmits white light.*
Light from a sodium lamp is shone at a Bunsen flame.	*There is no shadow of the flame.*	*The flame transmits sodium light.*
Sodium chloride is added to the flame.	*A shadow of the flame can be seen on the wall.*	*The sodium flame absorbs sodium light.*