THE JOURNEY OF IDEAS

CHAPTER 5: MEET FOUR ISLAMIC SCHOLARS

5.1. THE ASTRONOMER AL-SUFI BUILT A BRIDGE BETWEEN GREEK AND ISLAMIC ASTRONOMY

Al-Sufi was a famous Persian astronomer who was influenced by the Greek astronomers of Rhodes and Alexandria (see Chapter 3). The names of many prominent stars are Arabic and can be traced back to Al-Sufi's work. Examples are Aldebaran, Betelgeuse, Algol and Rigel. Ali-Sufi's full name was Abu 'l-Hussain 'Abd al-Rahman ibn Omar al-Sufi and he is known in the west as Azophi. He was born in Rey, Persia (today´s Iran), in the late 9th Century. Like other Moslem men of science he studied and wrote in Arabic. He carried out astronomical observations in the magnificent Persian city of Isfahan (now in Iran), where he became the Astronomer Royal to the Emir Adud al-Dawla, a man who ruled over large parts of today´s Iraq and Iran.

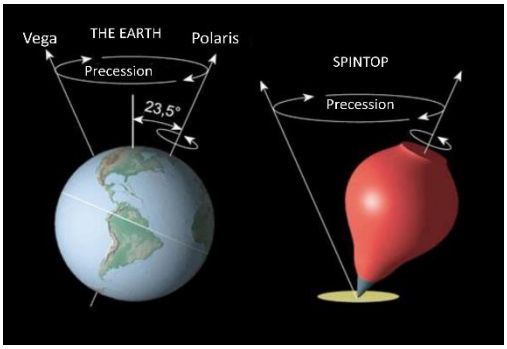
1.Al-Sufi (image credits: Scorza)

Adud al-Dawla realised the importance of science. After he became Emir, he sponsored a large number of scientific projects. In 960 he ordered the construction of a great dam between Shiraz and Estakhr. The dam irrigated about 300 villages and became known as Band-e Amir (the port of the Amir). On his orders, an observatory was built in Isfahan. It was at this observatory that Al-Sufi worked and continued mapping the night sky, just as Hipparchus and Ptolemy did 800 years before him. He painstakingly measured the positions and brightness of large numbers of stars as accurately as possible.

Why did Al-Sufi devote decades of his life to mapping the sky? What makes this work so important and interesting?

The answer lies in the work of the Greek scientist, Hipparchus, a thousand years before:

(a) Hipparchus noticed that the constellations seemed to shift very slowly on the sky as the year progressed. By measuring the positions of the constellations during spring and by comparing his measurements with those obtained by the Babylonian thousands of years before, he concluded that the sphere of the sky rotated. In reality it is the Earth's axis that rotates or processes like a spinning top. Because it! It takes 26.000 year for the Earth's axis to completely recess around, it is too slow to notice.

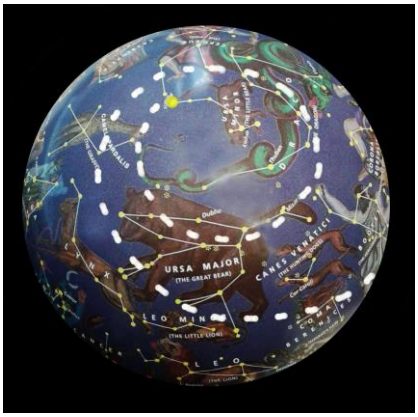


2. Earth precession (Credits: Earth and Planetary Magnetism Group Zurich)

(b) In 135 BC Hipparchus reported the appearance of a "new star" in the sky, (We now think that this star was probably a supernova - a dying star undergoing an enormous explosion.) This was a huge surprise since it had been thought that the sky was eternal, perfect and unchangeable. Afterwards Hipparchus kept observing the sky in case another surprising new star appeared! About 200 years before this Aristotle had realised the importance of making accurate descriptions of natural objects. His description and classification of plants laid the groundwork for the science of botany. A similar approach was adopted in astronomy: A first step in exploring the sky and the universe, was to make a catalogue of all objects in the sky. The second step consisted of comparing these objects with one another and trying to spot connections between them. [It is intriguing that during the 1800s, many centuries later, Darwin adopted the same research method, by listing and classifying plants and animals. Studying their similarities and differences led him to develop the theory of evolution].

Al-Sufi´s first task was to bring together Arabic and Greek constellations. In doing so he linked Greek and Islamic astronomy with each other and made himself and his Islamic culture legitimate heirs of the Greek tradition. His work of unifying the constellations was not easy, because the Arabs used different patterns and stars than the Greeks to represent the constellations (see activity 4.2.1 below). In the end he decided to adopt the Greek constellations (patterns of stars) and keep the Arabic names of most of the stars themselves. In a few cases where the names were "multicultural" and widely known, he kept the Greek star names, Other Arabic names of the stars were introduced throughout the centuries, but most star names used today came to us from Al-Sufi's original list.

In about 964 AD Al-Sufi summarized his observations in a work entitled “The Book of the Constellations”. Based on his own observations he gave a detailed description of the 48 Ptolemaic constellations taken from an Arabic translation of Ptolemy's Almagest. He observed and described the stars, their positions, their magnitudes and **for the first time introduced the colours of the stars**, setting out his results constellation by constellation starting with the circumpolar constellations (those located near the star Polaris, the North Pole star) and afterwards following a spiral path through the zodiac and beyond (see picture on the right).



3. Al-Sufis m3. Al-Sufis method of mapping the sky (credits: Scorza)

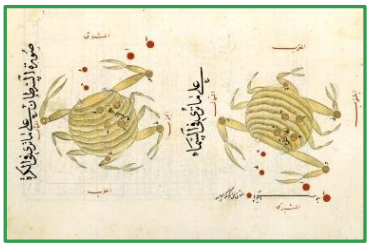
Despite the many legends about the constellations, Al-Sufi was not interested in Greek or Arabic mythology. He used the figures of the constellations merely as a gigantic “reference system” in the sky relative to which the positions of the stars could be measured.

In 964 AD while observing stars in the Andromeda constellation Al-Sufi made the earliest recorded observation of the Andromeda nebula, describing it as a "small cloud”. We now know that the Andromeda nebula is not a gas cloud but rather a “galaxy” - a giant family of thousands of millions of stars like our own Milky Way galaxy. Al-Sufi mentions it as lying before the mouth of a Big Fish, an Arabic constellation that was placed in front of Andromeda (see picture at the right). The Andromeda galaxy is the nearest galaxy to our own Milky Way and can be seen with naked eyes during the northern autumn.

4.The Andromeda galaxy as represented by Al-Sufi in his book (small dots in front of the mouth of the fish) and an image of the Andromeda galaxy (credits: ESO).

Using the constellations as a reference system, Al-Sufi found another cloud-like object, the Large Magellanic Cloud (LMC). We now know that the LMC is also a galaxy - a small satellite galaxy that goes around our Milky Way. He probably made this observation from Yemen, because the LMC was too far south to be seen from Isfahan. The LMC was not observed by Europeans until Magellan made his voyage to South America in the 16th century!

Al-Sufi also followed the practice of Hipparchus and Ptolemy in also using a globe to represent the night sky. The Greeks had imagined the sky as a sphere, with the Earth in its middle. The stars were imagined to be fixed, while the planets and the Sun moved along orbits fixed as concentric spheres. In his "Book on the Constellations" Al-Sufi introduced the idea of representing the constellations as we see them directly in the sky from our observing location on the Earth (left picture below) and as we see them when looking upon a sky globe, "from outside the celestial sphere".



5.Lefts: Sky globe from 200 AD (credits: Römisch-Germanischen Zentralmuseum in Mainz).

Al-Sufi´s Legacy

6.GAIA (credits: ESA)

Just like Al-Sufi, present-day astronomers often survey the sky and observe how various stars and galaxies change in position and brightness. Since Galileo first observed the sky with a telescope in the 17th Century, astronomers have built larger and larger telescopes and reached deeper and deeper into space. During the last half century they have even launched telescopes into space. Mapping the sky from space avoids blurring due to the Earth's atmosphere that causes stars to twinkle. The European Space Agency's GAIA satellite is such a telescope that is measuring the positions, brightness and distances of more than one billion stars! If Al-Sufi were alive today he would surely be amazed and delighted to see how the work that he begun is being continued by astronomers of our own time!

Activities of the chapter

Activity 5.1.1: Help Al-Sufi match the Greek and Arabic constellations

Ages: 7-14

Brief description

Following the steps of the Persian astronomer Al-Sufi, pupils are invited to search for and match the corresponding pairs of Arabic constellations (seen by Arabic tribes in the sky) and Greek constellations describing the same group of stars.

Learning objectives and skills

Pupils will learn about the work of Al-Sufi in relating the Greek constellations to the Arabic ones through hand-on activities. They will be shown the importance of measuring the positions of stars accurately and of searching for patterns among groups of stars.

Background information

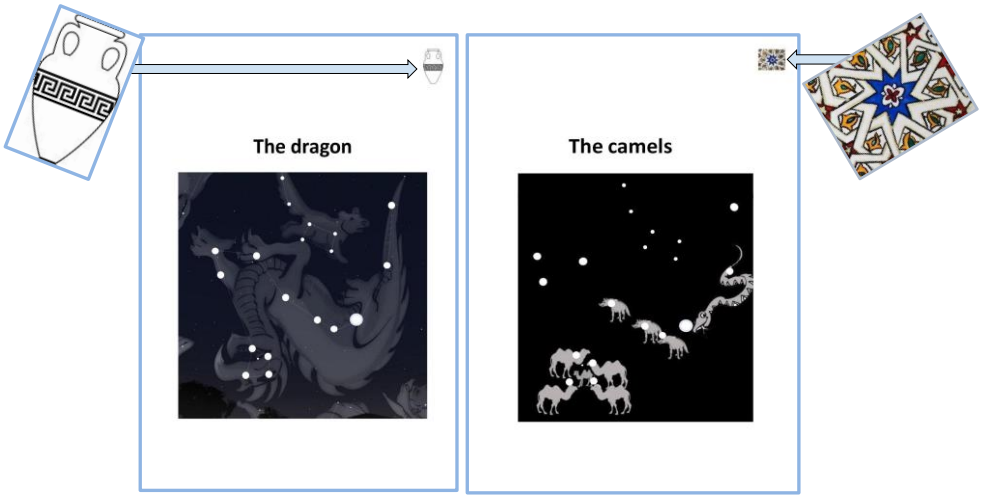
The astronomer Al-Sufi lived and worked in the magnificent city of Isfahan in the late 9th Century. Try to find this city on the map of the "Journey of Ideas"! Al-Sufi drew maps of the night sky and improved on the charts drawn by the ancient Greeks. For several years he compared the constellations imagined by the Greeks with those of the Arabic tradition and tried to identify which stars were common to both. He ended up by choosing the Greek constellations for his "Book of the Constellations" but kept the Arabic names of the stars from his own culture. You can best understand what a great person he was to by joining him at work!

Material

- Set of cards "Arabic and Greek constellations"

Description of the activity

Take the cards "Arabic and Greek constellations". Note the Greek symbol of a vessel on the Greek constellation cards (right upper corner) and the piece of Arabic mosaic on the Arabic ones. Mix all the cards thoroughly. Now search for the pairs of Greek and Arabic cards containing the same group of stars. Look carefully at the patterns and distributions of stars. After you think that you have found the overlapping pairs, turn around the cards to check whether you are correct.



7. Card game Greek and Arabic constellations (image credits: Scorza)

Activity 5.1.2: Discover Arabic star names and their meanings

Ages: 7-14

Brief description

Following the steps of the great Persian astronomer Al-Sufi, pupils are invited to match groups of stars with the corresponding Greek constellation, to learn the Arabic names of the brightest stars therein and what their names mean. We still use these names today but know little about their meanings or how to pronounce them.

Learning objectives and skills

By comparison and by pattern recognition pupils learn to match groups of stars with their corresponding constellations. They also gain insight in the meaning of the Arabic names of the brightest stars as well as in their pronunciation.

Background information

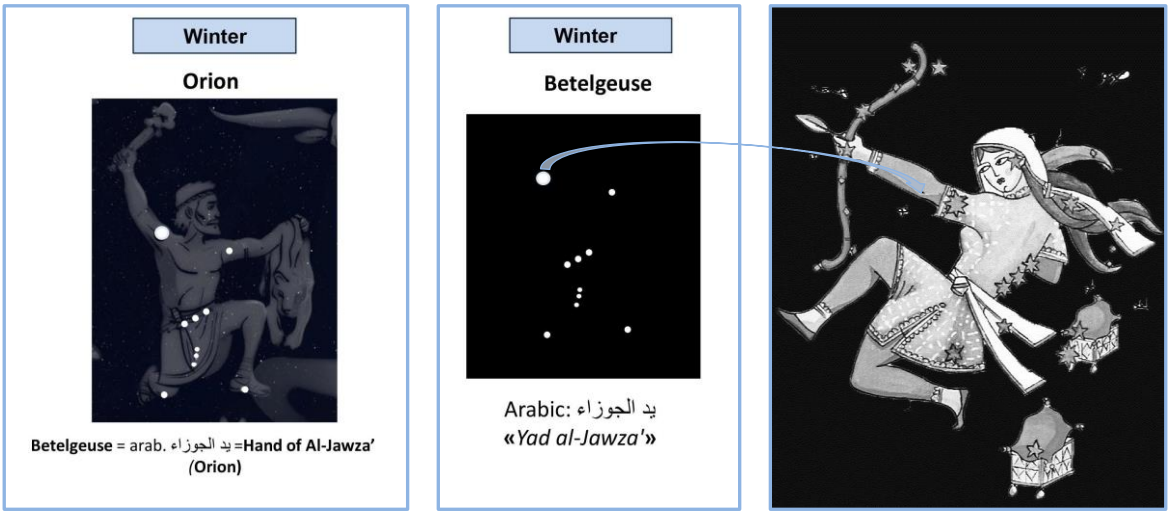
Although other Arabic star names were introduced later, those selected by Al-Sufi in his "Book of the Constellations" comprise the largest list of Arabic star names that we use today. Many of these star names are linked to the original Arabic constellation of which they once formed part. For instance "Betelgeuse" is the brightest star of the Orion constellation. It means "the Hand of Al-Jawza", the hunting goddess which a group of Arabs used to worship and saw at the sky on the place of Orion.

Material

Set of cards: "Arabic star names"

Description of the activity

Take the cards "Arabic star names" and mix on one side the largest cards (A) containing Greek constellations and the narrow ones (B) containing only the group of stars and the pronunciations of the names below. Look for the corresponding pairs by matching the constellations with the figures (see left Orion) on it with the group of stars ("Betelgeuse card"). Just as with the previous activity spot the patterns formed by the stars.



8. Card game the Arabic names of the stars (image credits: Scorza)

Activity 5.1.3 Discover the colors of the stars

Ages: 9-14

Brief description

Al-Sufi was the first astronomer that recorded the colour of the stars in a catalog. Following the steps of this Persian astronomer and by visualizing the constellations with a viewer and after in the night sky, pupils discover that stars not only differ in brightness but also in colour. Linking this important property of the stars to modern astronomy, they also explore how the colours of the stars are related to their temperature.

Learning objectives and skills

Pupils learn that stars have different properties that can be measured directly (brightness, colours) or indirectly (temperature). They also learn by analogy to relate the colours of the stars with another important property: their temperature.

Background information

When Al-Sufi started to observe the stars in Isfahan, he noticed the colours of some stars differed from others. This difference in colour had never been noted or recorded by Greek, Babylonian nor Egyptian astronomers! Al-Sufi thought that the colour is an important property of the stars and included it his catalogue together with their brightness's and positions. Stars are hot due to nuclear fusion in their central regions: due to the high pressure, cores of atoms (like hydrogen) collide and fusion into heavier ones (Helium) and into Carbon, Oxygen, etc. giving rise to the elements that we know in chemistry.

Materials

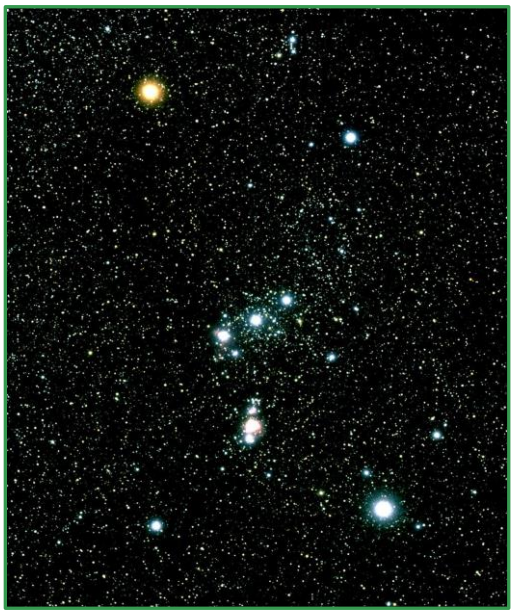
- Set of images of this activity
- Constellation viewer (see chapter 3)

Description of the activity

(a) Look carefully at the Orion constellation: Do you remember the name of the corresponding Arabic constellation? (See activity 5.1.1)

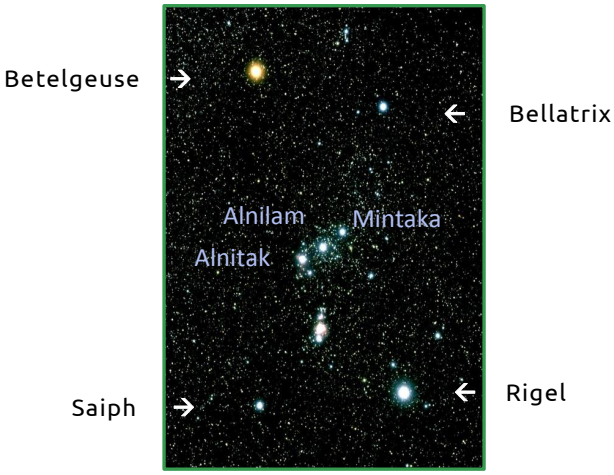
(b) Do you remember the name of the brightest star in the Orion constellation and what it means?

(c) Do you notice any difference between the colours of the stars in this constellation? What star colours do you see?



9. Orion constellation (credits: Hubble/ESA)

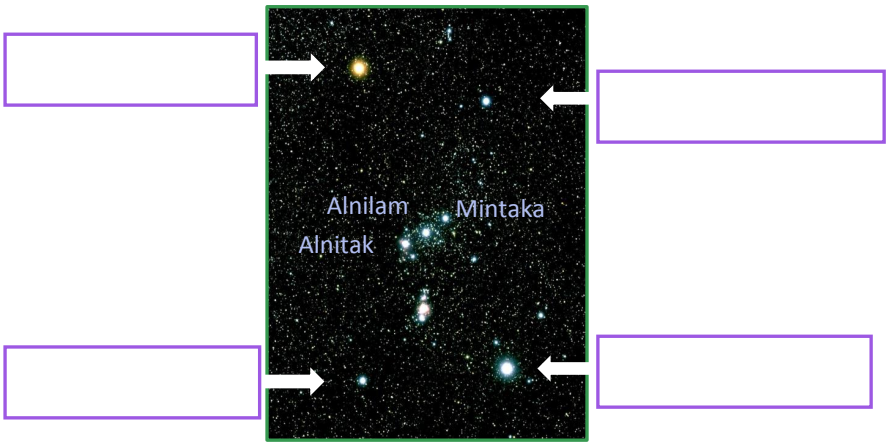
(d) Al-Sufi kept and used the Arabic names of stars in the Orion constellation in his "Book of the Constellations". You can find the meaning in the table below:



10. Orion constellation (credits: Hubble/ESA)

Name	Origin	Meaning
Betelgeuse	Arabic الجوزاء إبط	Hand of Al-Jawza
Bellatrix	Latin	Female Worrier
Saiph	Arabic سيف	Sword
Rigel	Arabic الرجل	Foot
Alnitak	Arabic النطاق	Belt
Alnilam	Arabic النظام	Belt of pearls
Mintaka	Arabic منطقة	Girdle

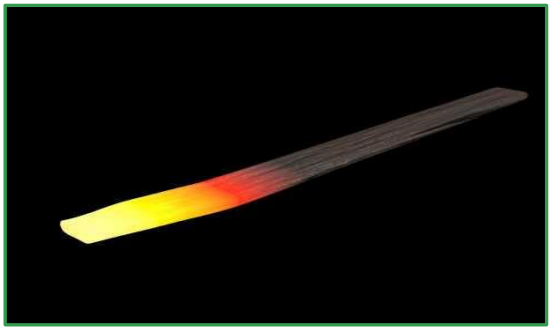
Cover the above picture of Orion with a piece of paper. Try to fill in the names of the four stars from the table in the picture bellow:



11. Orion constellation (credits: Hubble/ESA)

The colours and temperature of the stars

Have you ever seen an iron bar heated on the fire? In case not, just have a look at the picture bellow. When the iron bar is heated and become hotter and hotter, it turns red, then yellow, then white and finally (before it melts) blue!



12. Orion constellation (credits: Hubble/ESA)

(e) Look at the picture of stars taken with the NASA/ESA Hubble Space Telescope and try to answer the following questions:

13. Credit: HST image

- Which are the hottest stars?
- Which are the coldest ones?
- Which stars have a medium temperature?
- Does our Sun have a high, low or medium temperature?

We now know that stars have different colours because they are made up of hot glowing gas of different temperatures. Just as in the case of the iron bar, the star colours depend on how hot they are. The temperature of stars can sometimes reach 40 Million degrees in their inner cores! Al-Sufi didn´t know that the colours of stars are related to their temperatures, but he would certainly have loved to discover it!

(f) Take the constellation viewer and insert one after the other the cards with the following constellations:

- Orion
- Great Bear
- Lyon
- Lyra
- Taurus
- Scorpio

14. Credits: Scorza

For each constellation complete the table below: write the names of the brightest stars of these constellations, their colors as you see them in the viewer and with help of the table below, find out their temperatures:

Constellation name	Name of the brightest star	Color	Temperature

Surface temperatures in °C	Colour of the star	
30000 – 60000	Blue	
10000 – 30000	Blue white	
7500 – 10000	White	
6000 – 7500	Yellow white	
5000 – 6000	Yellow	
3500 – 5000	Orange	
< 3500	Red	

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