THE EARLY STAGES OF ORION STUDIES

GRAŻYNA STASIŃSKA

OLD REPRESENTATIONS OF ORION

http://members.westnet.com.au/gary-david-thompson/page11-30.html

Ptolemy's *Almagest* was first translated into Arabic circa 827. The first competent (clear), thorough, non-mathematical (descriptive) summary of Ptolemy's *Almagest* into Arabic was carried out by the Egyptian astronomer and geographer Abd al-Abbas al-Farghani. Its title was *Elements of Astronomy* and was written in the period between 833 and 857. Al-Farghani was born in Farghana (present-day Fergana), Uzbekistan, and died in Egypt. The first contacts of (Latin-speaking) Europeans with Arab-Islamic science dates to late 10th-century CE Catalonia (Spain).

Paul Kunitzsch proposes that the Arabic title "al-Majisti" and "Almagest" (= "greatest treatise") derives from a Pahlavi (Middle Persian) form. The Arabic-transliterated title betrays the route by which the *Syntaxis* reached Europe. Although a Latin translation of the *Almagest* was made from a Greek manuscript in Sicily, circa 116O CE, this version was not disseminated. Rather, Arabic translations were the means by which this major astronomical work of Ptolemy was reintroduced to Europe, until Greek manuscripts became available in Renaissance times. In Toledo, in 1175 CE, Gherardo of Cremona finished translating the text into Latin from Arabic, and this version was the most popular in medieval Europe.

The retransmitted Latin translation of Ptolemy's *Almagest* by Gherardo of Cremona in the 12th-century began the distorted use of Greek-Arabic-Latin words that appear in modern lists of star names. In Greek astronomy the stars within the constellation figures were usually not given individual names. Ptolemy did not identify the stars in his catalogue with Greek letters, as is done by modern astronomers. Each of the 1025 stars listed by Ptolemy (Book VII and Book VIII of the *Almagest*) was identified (1) descriptively by its position within one of the 48 constellation figures; then (2) by its ecliptic latitude and longitude; and then (3) its magnitude. When the Arabic astronomers translated Ptolemy's *Almagest*, and adopted the Greek constellations, they also applied their own star names to the listed stars. Beginning with Gherardo, when the Arabic texts of the *Almagest* were translated into Latin, the Arabic star names were retained but were frequently translated in a corrupted form. The medieval European astronomers adopted the system of using individual (Arabic) star names in their uranography. Hence the star names we use today were essentially introduced by the medieval European translators of Arabic texts of Ptolemy's *Almagest*, the translation from Arabic to Spanish of al-Sufi's *Book of the constellations of the Fixed Stars* (*Kitab suwar al-kawākib*).

The principal channel for the recovery of the *Almagest* in Western Europe was the Arabic to Latin translation by Gherardo of Cremona. It was made at Toledo using several Arabic versions and completed no later than 1175. It was widely circulated in manuscript copies before appearing as a printed book in 1515.Gherardo's translation was the only version of Ptolemy's *Almagest* known in Western Europe until the later discovery of copies of the original Greek texts and their translation into Latin texts in the 15th-century. Ptolemy's *Almagest* in the original Greek continued to be copied and studied in the eastern (Byzantine) empire. In the 15th-century European scholars, first George of Trebizond and then Johannes Regiomontanus, independently translated Ptolemy's *Almagest* from copies of the original Greek text.

Gherardo of Cremona was born in Cremona, Lombardy (Italy) circa 1114 and died in Toledo in 1187. He is most famous as the translator of Ptolemy's *Almagest* from Arabic texts found in Toledo. His specific initial intention was to learn Arabic so that he could read Ptolemy's *Almagest*. (Gerardo had left Italy mainly in quest of Ptolemy's *Almagest*.) At the time known copies of Ptolemy's *Almagest* only existed in the Islamic world (in Arabic and Syriac (a pre-Islamic language of ancient Syria). Even though no Latin copies existed up to the 12th-century it retained its traditional high reputation among European scholars. Gherardo was one of a small group of European scholars who revitalised medieval European astronomy in the 12th-century by transmitting Greek and Arabic science texts to the West in the form of translations into Latin. (It was Islam's conquest of Spain that would bring the seeds of modern astronomy to Europe.)

It is estimated that up to 1,000,000 Arabic books were burnt when the Catholic monarchs regained control of Moorish Spain. The southern Spanish cities of Toledo, Cordova, and Seville became the most important centres for the transmission of Arabic scientific texts into medieval Europe. What resulted in Europe was a polyglot system of Greek constellations with Latin names containing stars with (largely) Arabic titles.

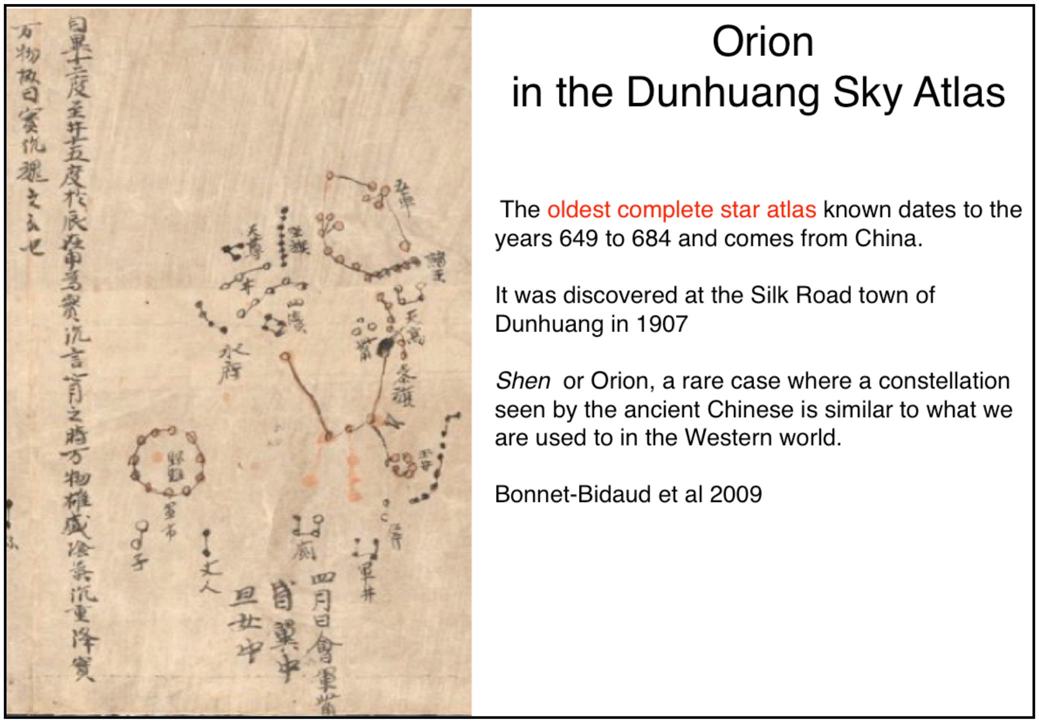
The Greek myth of Orion

Orion (Ωριων, The mountain man ?)
was a handsome giant, sun of Poseidon, and the hunting companion of the goddess Artemis. He died while in her service and was placed among the stars as a constellation.
The most common story about his death was that he bragged he would hunt down all the beasts of the earth, and so Mother Earth sent up a giant scorpion to kill him.

According to the Boiotians, Orion was born when the three gods Zeus, Poseidon and Hermes urinated on a bull-hide and buried it in the earth to provide King Hyrieus with a son. The boy was named Orion after the urine.

Orion on a ceiling fresco from the Villa Farnese in Caprarola, Italy, painted around 1573.

http://www.theoi.com/Cat_Astraioi.html
The main source for Greek star myths were the lost works of Hesiod and Pherecydes, and the later works of Pseudo-Eratosthenes, Aratus and Hyginus. Translations of these are available online at Theoi.com.
There are very few surviving depictions of the constellations in classical art: at most, a few Roman mosaics,
ORION Greek Name Transliteration Latin Spelling Translation Ωριων Ôriôn Orion Urine (ourios), Of the Mountain (oros)
ORION was a handsome giant gifted with the ability to walk on water by his father Poseidon. He served King Oinopion of Khios (Chios) as huntsman for a time, but was blinded and exiled from the island after raping the king's daughter Merope. Orion then travelled across the sea to Lemnos and petitioned the god Hephaistos for help in recovering his sight. Lending him his assistant Kedalion, the god directed the giant travel to the rising place of the sun, where the sun-god would restore his vision. Upon returning to Greece, Orion sought out Oinopion, but the king hid himself in an underground bronze chamber to avoid retribution.
After this the giant retired to the island of Delos or Krete and became a hunting companion of the goddess Artemis. He died while in her service and was placed amongst the stars as the constellation Orion. The circumstances of his death are variously related. In one version he desired to marry the goddess but her brother Apollon tricked Artemis into shooting him with an arrow as he was swimming far out at sea. In another version, Artemis killed him deliberately after he raped her attendant Oupis. However the most common story was that Orion bragged he would hunt down all the beasts of the earth, and so Mother Earth sent up a giant scorpion to destroy him. Both the giant and scorpion were placed amongst the stars, one rising as the other set.
Finally the Boiotians had their own set of myths associated with the hunter of the constellation. According to their version Orion was born when the three gods Zeus, Poseidon and Hermes urinated on a bull-hide and buried it in the earth to provide King Hyrieus with a son. The boy was named Orion after the urine
Latin : Orion Greek : Ôriôn (the Mountain Man?) Akkadian : Shidallu (the True Shepherd of Anu)
Sumerian : SIPA.ZI.AN.NA (the True Shepherd of Anu)
A giant hunter who was set amongst the stars as the constellation Orion. Some say he chased Lepus, the hare, across the heavens with his dog, the constellation Canis, others that he was in pursuit of Taurus the bull, or even chasing after the seven beautiful Pleiad nymphs. In the story of his death, Orion was either killed by Artemis or by a scorpion sent by Gaea to punish him for boasting that he would slay all the creatures of the earth. The scorpion was also placed amongst the stars and continued to plague him, for as it rose in the east, Orion fled beneath the horizon in the west. (Hyginus 2.34 on Hesiod, Aristomarchus and Istrus ; Aratus 634)



In the early twentieth century, a secret cave, now known as the 'Library Cave', was discovered in the Buddhist Mogao cave complex (Mogaoku 莫高窟), just outside the Silk Road town of Dunhuang in northwest China. This cave had been sealed for a thousand years and contained around forty thousand manuscripts, paintings and printed documents on silk and paper. Among them, was a manuscript containing the oldest manuscript star atlas known today from any civilisation, probably dating from around AD 700. It shows a complete representation of the Chinese sky in 13 charts with over 1300 stars named and accurately presented. The chart contains much information that has proved very useful for modern astronomers.

The Dunhuang Star Atlas was not the only astronomical document found in the Dunhuang Library Cave. Along with a fragment of a circumpolar star map and an astrological compilation of the Chinese constellations, the discovery of these documents revealed a fascinating snapshot of astronomical knowledge in ancient China. Its discovery was a huge surprise since such an early chart had never before been seen from any civilization. But the first mention of the chart in an astronomical context appears to be made by Joseph Needham as late as 1959 in his *Science and Civilisation in China* .

The atlas itself forms the second part of a longer scroll (Or.8210/S.3326) that measures 210 cm long by 24.4 cm wide and is made of fine paper in thirteen separate panels. The first part of the scroll is a manual for divination based on the shape of clouds. The twelve charts showing different sections of the sky follow these. The stars are named and there is also explanatory text. The final chart is of the north-polar region. The chart is detailed, showing a total of 1345 stars in 257 clearly marked and named asterisms, or constellations, including all twenty-eight mansions. For a hand-drawn document the positioning is very accurate and stands up well to comparison with modern charts.

Because astronomy was considered a matter of state, the distribution of documents like this would have been strictly controlled and limited to military and governmental use. This may explain why so few charts of this sort exist today. As Dunhuang, the place of discovery, is a remote town where it is unlikely astronomical observations would have been recorded, it seems likely that the chart was brought to Dunhuang by an official from the Chinese capital.

The importance of the chart lies in both its accuracy and graphic quality. The chart includes both bright and faint stars, visible to the naked eye from north central China, and was probably used as a reference material. Its origins and real use remain unknown.

The Dunhuang Star Atlas is now held at The British Library in London along with many other items from the Library Cave and other ancient Silk Road sites. These unique items tell fascinating stories of life on the Silk Road from 100 BC to AD 1400. Most of these collections were dispersed to institutions worldwide in the early twentieth century, making it difficult to study them as a whole. The International Dunhuang Project (IDP) based at the British Library is now making these resources freely accessible to all via this multi-lingual website.

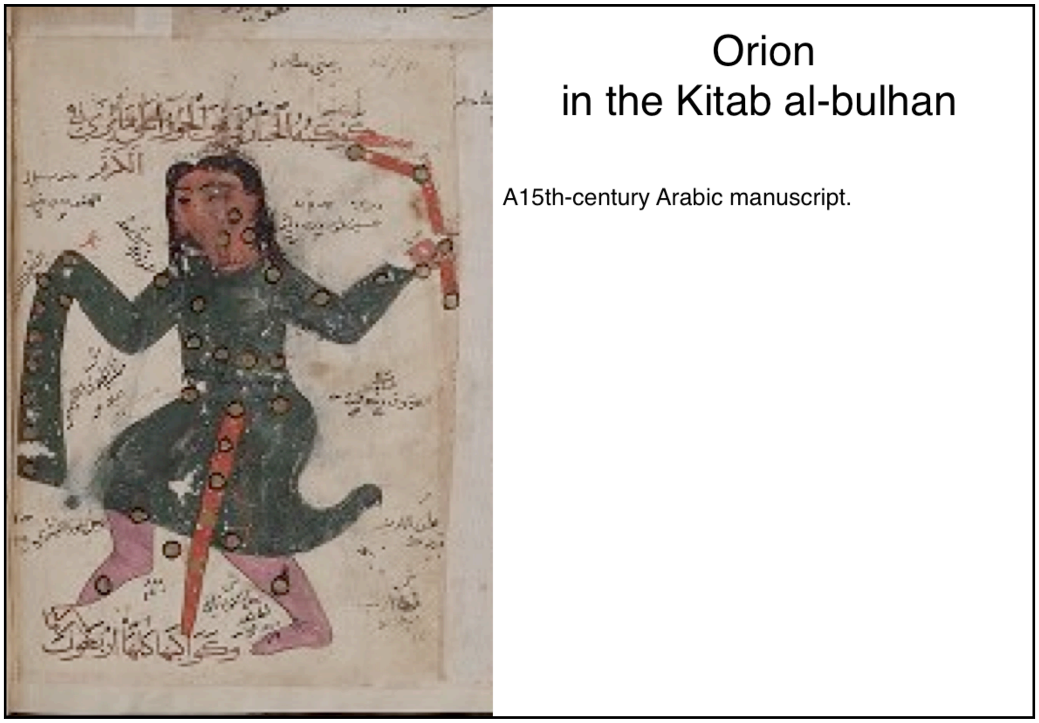
Orion in
the Book of Fixed Stars

Al-Sufi, 964

Based on Ptolemy's Almagest
with Arabic star names
and drawings of the constellations.

Orion is called al-jabbar (the giant)

Abd-al-Rahman Al Sufi (December 7, 903 - May 25, 986 A.D.)
Abd-al-Rahman Al Sufi (or Abr-ar Rahman As Sufi, or - according to R.H. Allen (1899) - Abd al Rahman Abu al Husain, sometimes referred to as Azophi) was living at the court of the Emire Adud ad-Daula in Isfahan (Persia), and working on astronomical studies based on Greek work, especially the Almagest of Ptolemy. He contributed several corrections to Ptolemy's star list, in particular he did own brightness/magnitude estimates which frequently deviated from those in Ptolemy's work. Also, he was the first to attempt to relate the Greek with the traditional arabic star names and constellations, which was difficult as these constellations were completely unrelated and overlapped in a complicated way. Al Sufi published his famous *"Book of Fixed Stars"* in 964 (Al Sufi, 964), describing much of his work, both in textual descriptions and pictures. In his descriptions and pictures of Andromeda, he included "A Little Cloud" which is actually the Andromeda Galaxy M31. He mentions it as lying before the mouth of a Big Fish, an Arabic constellation. This "cloud" was apparently commonly known to the Isfahan astronomers, very probably before 905 AD. In this book, he probably also cataloged the Omicron Velorum cluster IC 2391 as a "nebulous star", and an additional "nebulous object" in Vulpecula, a cluster or asterism now known as Al Sufi's or Brocchi's Cluster, or Collinder 399. Moreover, he mentions the Large Magellanic Cloud as **Al Bakr**, the White Ox, of the southern Arabs as it is invisible from Northern Arabia because of its southern latitude.
Al Sufi's observations were not known in Europe at the time of the invention of the telescope,



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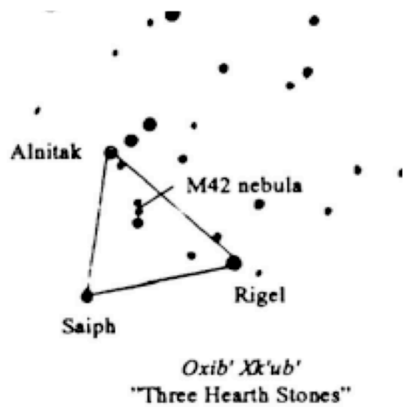
Kitab al-Bulhan or Book of Wonders (late 14thC.)
The Kitab al-Bulhan, or Book of Wonders, is an Arabic manuscript dating mainly from the late 14th century A.D. and probably bound together in Baghdad during the reign of Jalayirid Sultan Ahmad (1382-1410). The manuscript is made up of astrological, astronomical and geomantic texts compiled by Abd al-Hasan Al-Isfahani, as well as a dedicated section of full-page illustrations, with each plate titled with “A discourse on….”, followed by the subject of the discourse (a folktale, a sign of the zodiac, a prophet, etc.).

Orion in Maya Astronomy



Three stars in the constellation Orion (the great blue giant, Rigel, Kappa Orionis, the star Saiph and the belt star, Alnitak) form an equilateral triangle called, Oxib X'kub' or "The Three Stones of the Hearth"

"Orion is depicted in the Madrid Codex as a turtle with three stone glyphs on its back."

http://www.authenticmaya.com/maya_astronomy.htm

Orion: *The Maya called Orion Ak' Ek' or "Turtle Star", Orion is depicted in the Madrid Codex as a turtle with three tun ("stone") glyphs on its back. Because the sky has not yet been raised, before the creation, the hearth is a location in both earth and sky. The turtle shell is an earth symbol, like the back of the crocodile at the foot of the World Tree. Here is the place of Creation, where the sky will rise and saw the nearby ecliptic constellation of Gemini as the mother peccary and the belt stars are her children. In addition, the Maya used three stars in the constellation Orion: The great blue giant, Rigel, Kappa Orionis, the star Saiph and the belt star, Alnitak. These three stars form an equilateral triangle called, Oxib X'kub' or "The Three Stones of the Hearth". They represent the Maya hearth, made of three stones placed in a triangular pattern. The hearth was and is the very foundation of the Maya home. Directly in the center of the Three Stones of the Hearth, you will find the Orion nebula, M42. It acts as the flame called, "K'ak". Toward dawn on the Creation night of Aug 13, the constellation Orion moves toward the zenith. The K'iche' people still refer to a triad of three bright stars in Orion as "the hearth stones", and the hazy nebula below Orion's belt is called "the smoke from the hearth".*

The Popol Vuh, proven to be the true Maya creation myth, since the Preclassic, (San Bartolo Murals), and Classic, (Quiriguá's Stela C), that was preserved by the Postclassic K'iche' Maya, in the Guatemala Highlands. In this book, Orion was seen as the First Father, who was known as Hun Hunahpú, The Maize god, the father of the Hero Twins, Hunahpú and Xbalanqué, that were fundamental in their Mythology.

Uranometria is the short title of a star atlas produced by Johann Bayer. It was published in Augsburg, Germany, in 1603 by Christophorus Mangus under the full title *Uranometria : omnium asterismorum continens schemata, nova methodo delineata, aereis laminis expressa.* This translates to "Uranometria, containing charts of all the constellations, drawn by a new method and engraved on copper plates". The word "Uranometria" derives from Urania, Muse of the heavens and "uranos" (*ουρανός*) the Greek word for sky / heavens. A literal translation of "Uranometria" is "Measuring the Sky" (to be compared with "Geometry"-*"Geometria"* in Greek, literally translated to "Measuring the Earth").

It was the first atlas to cover the entire celestial sphere.

Each plate includes a grid for accurately determining the position of each star to fractions of a degree. The positions used by Bayer to create the *Uranometria* were taken from the expanded 1,005 star catalog of Tycho Brahe. Brahe's expanded list had circulated in manuscript since 1598 and was available in graphic form on the celestial globes of Petrus Plancius, Hondius, and Willem Blaeu. It was first published in tabular form in Johannes Kepler's Tabulae Rudolphinae of 1627.

The use of Brahe's catalog allowed for considerably better accuracy than Ptolemy's somewhat limited star listing. The stars listed in *Uranometria* total over 1,200, indicating that Brahe's catalog was not the only source of information used. Bayer took the southern star positions and constellation names for the 49th plate from the catalog of Dutch navigator Pieter Dirkszoon Keyser, who corrected the older observations of Amerigo Vespucci and Andrea Corsali, as well as the report of Pedro de Medina. *Uranometria* contains many more stars than did any previous star atlas, though the exact number is disputed as not all stars on the charts are labeled.

Each of the constellations' stars are overlayed on an engraved image of the subject of the constellation. For reasons unknown, many of the human constellations are engraved as figures seen from behind whereas they had traditionally been rendered as facing the Earth. This oddity led to some confusion in the literal meanings of certain star names (e.g. the origins of several named stars refer specifically to "right shoulder" and the like, which would be incorrect given *Uranometria's* illustrations).

Orion in Hevelius's Uranografia (Gdansk 1690)

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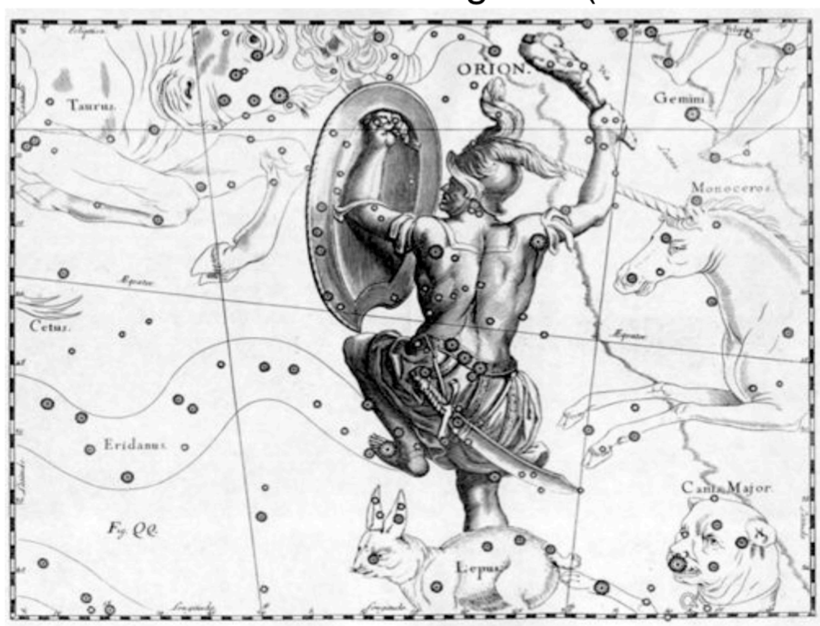
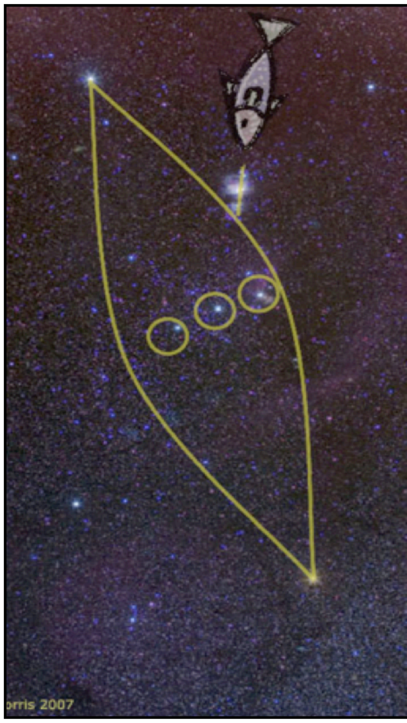


Hevelius, Johannes. *Firmamentum Sobiescianum sive Uranographia*. Gdansk, 1690.
The Hevelius *Firmamentum* was the first star atlas to rival Bayer's *Uranometria* in accuracy, utility, innovation, and influence. Hevelius was perhaps the most active observational astronomer of the last half of the seventeenth century. His star atlas is notable for many reasons. It contains fifty-six large, exquisite, double-page engraved star maps. The star positions for the charts were derived from Hevelius's own star catalog, based on his own observations, which was first published along with the atlas. It is unique among the Grand Atlases in choosing to depict the constellations as they would appear on a globe, that is, from the outside looking in, rather than from a geocentric point of view, as Bayer and most others adopted. So Aquila and Antinous swoop down to the right, rather than to the left as in Bayer

SURVIVING MYTHS AND LEGENDS
OF ORION



Orion
for the Yollngu
aborigen people from Australia

The three stars represent three brothers from the king-fish clan who went fishing on a canoe (whose nose is the star Betelgeuse and stern is the star Rigel).

One of them ate a fish that was forbidden. The Sun-woman (Walu) saw this, and was so angry at him for breaking the law that she created a waterspout that lifted them right up into the sky.

The image above shows the constellation Orion, which is also known in Australia as "The saucepan". The Yolngu people of the Northern territory know it as Djulpan.
Notice the three stars in a row above, which in classical Greek mythology represent Orion's belt. Above them is the famous Orion nebula, only 1000 light-years away from us, where new stars are being born. Greek mythology says this is Orion's sword, which is above his belt because he is standing on his head when seen from Australia! To the bottom right (the bow of the canoe) is the red giant star Betelgeuse, and to the top left (the stern of the canoe) is the star Rigel. these are Orion's hand and feet respectively.
A traditional Yolngu story tells how three brothers of the King-fish (Nulkal) clan went fishing, but all they could catch were king-fish. Because they were in the king-fish clan, traditonal lore forbade them to eat these fish, and so they had to throw them back into the water. Eventually, one of the brothers became so hungry that he decided to break the law, and caught and ate a king-fish. The Sun-woman (Walu) saw this, and was so angry at him for breaking the law that she created a waterspout that lifted them right up into the sky, where you can still see them. The three brothers are the three stars across the centre of the canoe, and the Orion nebula is the fish trailing on its line in the water. Thus this constellation is a reminder that you'd better not break the law!
The Kuwema people, near Katherine in the Northern territory, knew that when Orion rose in the early morning in winter, then the Dingoes would start mating, producing puppies which were an important source of livelihood for the Kuwema people.

This web site is dedicated to the hundreds of thousands of Indigenous Australians who lost their lives after the British occupation of Australia in 1788.
http://www.atnf.csiro.au/research/AboriginalAstronomy/whatis.htm

Orion
for the indians in Brazil:
Tupinamba and Guarani

is the leg of the Old Man.

The Old Man had a wife who was in love with his brother.

To stay with the brother, the wife killed the Old Man, and cut out his leg.

The gods pitied the Old Man and took him to the heavens.

Tradições astronômicas tupinambás na visão de Claude D'Abbeville
FLÁVIA PEDROZA LIMA Museu de Astronomia e Ciências Afins – MAST/MCT
ILDEU DE CASTRO MOREIRA Instituto de Física – UFRJ
ABSTRACT: This work presents one of the most important historical reports about Brazilian indigenous groups: Histoire de la mission des pères capucins en l'isle de Marignan et terres circonvoisines où est traicté des singularitez admirables & des moeurs merveilleuses des indiens habitans de ce pais, by Claude D'Abbeville, published in 1614. This report contains descriptions about constellations, calendar systems and some empirical astronomical knowledge. Outra constelação citada por D'Abbeville é a do HomemVelho:"Há uma outra [constelação] que eles chamam de Tuyvaé, isto é, Homem Velho, pois ela é composta de muitas estrelas dispostas na forma de um homem velho segurando um bastão".31
Os guaranis também reconhecem no céu uma constelação chamada *Homem Velho:*

A constelação do *Homem Velho* dos guaranis do Paraná contém três outras constelações indígenas, cujos nomes em guarani são: *Eixu* (as Plêiades), *Tapi'i rainhykã* (as Hyades, incluindo Aldebaran) e *Joykexo* (O Cinturão de Orion).34
http://books.google.pl/books?id=wO5PM25fdJIC&pg=PA24&lpg=PA24&dq=orion+tupinamba&source=bl&ots=1aKv6e1aGV&sig=SE-Si54QOyxe1uF1GcqSdEQWWX0&hl=fr&sa=X&ei=ihIDUMLpJYn04QTW96WmCA&redir_esc=y#v=onepage&q=orion%20tupinamba&f=false
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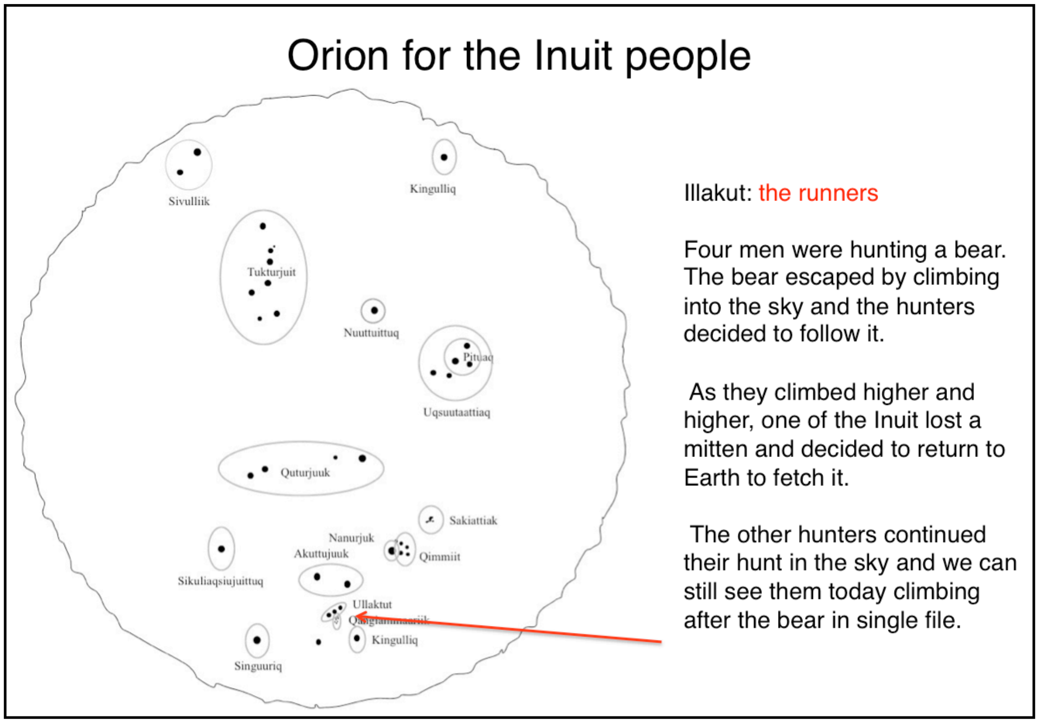
Conta o mito que essa constelação representa um homem cuja esposa estava interessada no seu irmão. Para ficar com o cunhado, a esposa matou o marido, cortando-lhe a perna. Os deuses ficaram com pena do marido e o transformaram em uma constelação.

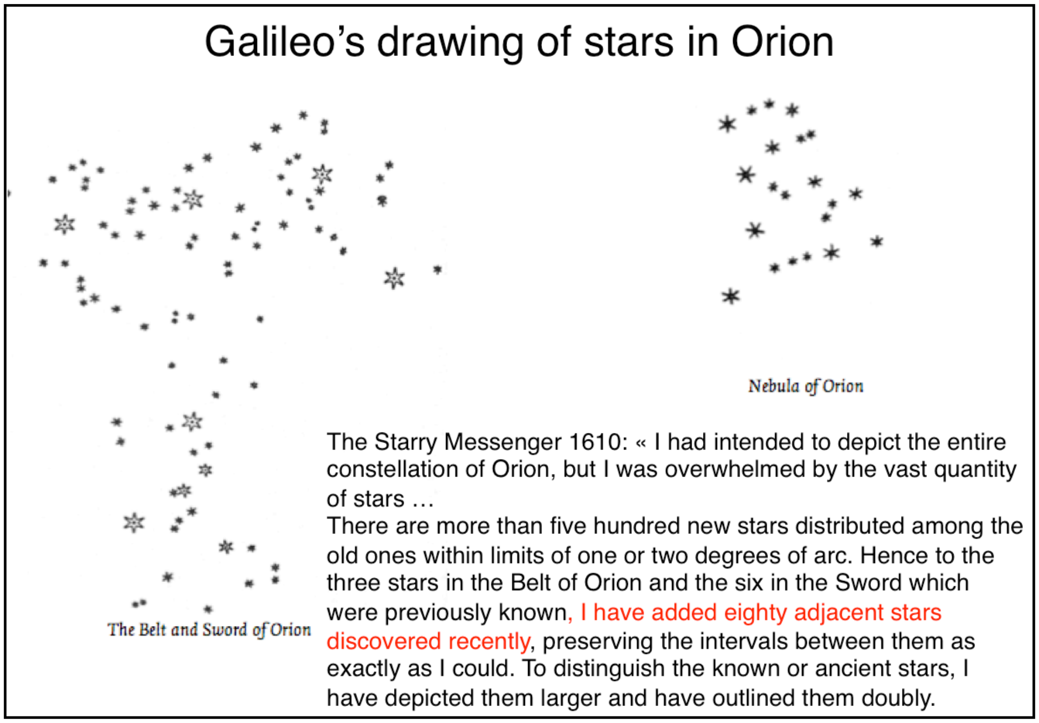


ULLAKTUT TOLD BY NOAH PIUGAATTUK

A legend relating to the constellation Ullakut – the three stars of Orion's belt.

In the legend they are known as Ullaktut (the runners). There are three stars, slanted upwards and evenly separated. They are most visible. Directly in front of these stars is a big star with many smaller stars around it. The big star is called Nanurjuk (the polar bear); ...the smaller stars are known as the Qimmiit (the dogs). The three runners-the Ullaktut-came across a polar bear at night and are known to have climbed up to the sky; that is the legend. They are quite visible. They are used for navigational purposes because they are easy to identify. The Ullaktut legend has it that there were three runners...actually there were four of them. They were out hunting and, during the night, they came upon a polar bear. As they were chasing the bear, one of the runners got really hot and took off his mitts. As he ran he dropped his mitts. After a while, this runner noticed he didn't have his mitts, so he went back for them and that is how he returned to Earth. He was the fourth person. Had he continued after the bear he would have been the fourth star. He was thus the only one of the runners that made it back to camp. That is the legend of the Ullaktut stars.

ORION
THROUGH A TELESCOPE



In the first I had intended to depict the entire constellation of Orion, but I was overwhelmed by the vast quantity of stars and by limitations of time, so I have deferred this to another occasion. There are more than five hundred new stars distributed among the old ones within limits of one or two degrees of arc. Hence to the three stars in the Belt of Orion and the six in the Sword which were previously known, I have added eighty adjacent stars discovered recent- ly, preserving the intervals between them as exactly as I could. To distinguish the known or ancient stars, I have depicted them larger and have outlined them doubly; the other (invisible) stars I have drawn smaller and without the extra line. I have also preserved differences of magnitude as well as possible.

And what is even more remarkable, the stars which have been called "nebulous" by every astronomer up to this time turn out to be groups of very small stars arranged in a wonderful manner. Although each star sepa- rately escapes our sight on account of its smallness or the immense distance from us, the mingling of their rays gives rise to that gleam which was formerly believed to be some denser part of the aether that was capable of reflecting rays from stars or from the sun. I have observed some of these constellations and have decided to depict two of them.
In the first you have the nebula called the Head of Orion, in which I have counted twenty-one star

THE DISCOVERY AND FIRST DRAWINGS OF THE ORION NEBULA

First descriptions of the Orion nebula

Nicolas Fabri de Peiresc 1610

In the middle of Orion .... Composed of two stars a nebula
The Nebula didn't appear in Orion. Serene sky.
The Nebula appeared again in Orion. The strength of the air was not sufficiently serene

Johann Baptist Cysatus in 1611

"Caeterum huic phaenomeno similis stellarum congeries est in firmamento ad ultimam stellam Gladii Orionis, ibi enim cernere est (per Tubum) cougestas itidem aliquot stellas angustissimo spatio et circumcirca interque ipsas stellulas instar albae nubis candidum lumen affesum."
Reported by R. Wolf in *Astronomische Nachrichten*, Vol. 38, No. 895 (1854), col. 109.

Google translation:
But this phenomenon is similar to a group of stars in the firmament of the last star of Orion The swords, for there is to be seen (by tube) cougestas also a few stars and a very narrow space between the little stars around like a white cloud of white light affesum.
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Jump to: navigation, search
Nicolas-Claude Fabri de Peiresc.
Nicolas-Claude Fabri de Peiresc (1 December 1580 – 24 June 1637), often known simply as **Peiresc**, or by the Latin form of his name **Peirescius**, was a French astronomer, antiquary and savant, who maintained a wide correspondence with scientists, and was a successful organizer of scientific inquiry. His research included a determination of the difference in longitude of various locations in Europe, around the Mediterranean, and in North Africa.

Johann Baptist Cysatus (1588 - March 3, 1657)
Johann Baptist Cysat (latinized Cysatus) was born in Lucerne, Switzerland in 1588 or 1586. He became Jesuit astronomer and student of Christoph Scheiner (1575-1650) in Ingolstadt, Germany. In 1611, with a telescope, Scheiner and Cysatus started observing sunspots, which they discovered independently from others (in particular Galileo), stimulated by a publication of Kepler. In 1616 or 1618, Cysatus succeeded Scheiner as professor of mathematics and astronomy. From 1623-7 he was Rector of the Jesuit College at Lucerne. 1627-8 he was sent to Spain, and in the 1630s, architect of the Jesuit church in Innsbruck. 1637-41 he chaired the Jesuit College in Innsbruck, 1646-50 the Jesuit College in Eichstätt. He later returned to Lucerne where he died in 1657. Cysatus was honored by naming a Lunar Crater after him (66.2S, 6.1W, 48.0 km diameter, in 1935).
Cysatus independently discovered the Orion Nebula M42 in 1611, one year after its original discovery by Peiresc. He published these observations in 1619, in his *Mathematica astronomica de cometa anni 1618* (Cysatus 1619). Nevertheless, this publication and discovery fell forgotten until their rediscovery by R. Wolf (1854); also see G. Bigourdan (1916). "Caeterum huic phaenomeno similis stellarum congeries est in firmamento ad ultimam stellam Gladii Orionis, ibi enim cernere est (per Tubum) cougestas itidem aliquot stellas angustissimo spatio et circumcirca interque ipsas stellulas instar albae nubis candidum lumen affesum."
Reported by R. Wolf in *Astronomische Nachrichten*, Vol. 38, No. 895 (1854), col. 109.

Huyghens's description of the Orion nebula 1656

8 CHRISTIANI HUGENII

Phænomenon in Orione novum.

Unum verò circa fixas phænomenon relatu dignum occurrit, à nemine hucuſque, quod ſciam, animadverſum, nec quidem niſi grandibus hiſce teleſcopijs rectè obſervandum. In Orionis enſe tres ſtellæ ab Aſtronomis reponuntur inter ſe proximæ. Harum mediam Anno 1656 fortè per tubum inſpicienti mihi, pro ſtella una duodecim (quod quidem minimè novum) ſeſe obtulerunt; eo poſitu quem ſubjecta figura expreſſimus,

Ex his autem tres illæ pene inter ſe contiguæ, cumque his aliæ quatuor, velut trans nebulam lucebant, ita ut ſpatium circa ipſas, qua forma hîc conſpicitur, multo illuſtrius appareret reliquo omni cælo; quod cum apprimè ſerenum eſſet ac cerneretur nigerrimum, velut hiatu quodam inter-

I detected among the fixed stars an appearance resembling nothing which had ever been seen before, so far as I am aware. This phenomenon can only be seen with large telescopes…. as I was looking, in the year 1656, through my 23-feet telescope, at the middle of the sword, I saw, in place of one star, no less than twelve stars-which indeed is no unusual occurrence with powerful telescopes. Three of these stars seemed to be almost in contact, and with these were four others which shone as through a haze, so that the space around shone much more brightly than the rest of the sky. …. All this I have continued to see up to the present time …, so that this singular object, whatever it is, may be inferred to remain constantly in that part of the sky.

I certainly have never seen anything resembling it in any other of the fixed stars. For other objects once thought to be nebulous, and the Milky Way itself, show no mistiness when looked at through telescopes, nor are they anything but congeries of stars thickly clustered together.

Light Science For Leisure Hours | by Richard A. Proctor 1873 The great nebula in orion
Read more: http://chestofbooks.com/science/astronomy/Leisure-Hours/#ixzz20F8BpP44

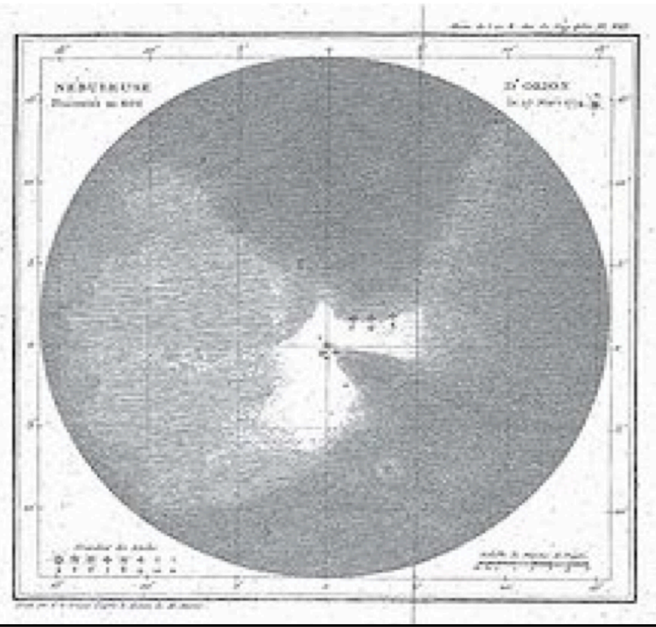
That Hevelius, 'the star-cataloguer,' should have failed to detect the Orion nebula is far less remarkable; for Hevelius objected to the use of telescopes in the work of cataloguing stars. He determined the position of each star by looking at the star through minute holes or pinnules, at the ends of a long rod attached to an instrument resembling the quadrant.

The actual discoverer of the great nebula was Huy-ghens, in 1656. The description he gives of the discovery is so animated and interesting, that we shall translate it at length. He says:

'While I was observing the variable belts of Jupiter, a dark band across the centre of Mars, and some indistinct phenomena on his disc, I detected among the fixed stars an appearance resembling nothing which had ever been seen before, so far as I am aware. This phenomenon can only be seen with large telescopes such as I myself make use of. Astronomers reckon that there are three stars in the sword of Orion, which lie very close to each other. But as I was looking, in the year 1656, through my 23-feet telescope, at the middle of the sword, I saw, in place of one star, no less than twelve stars-which indeed is no unusual occurrence with powerful telescopes. Three of these stars seemed to be almost in contact, and with these were four others which shone as through a haze, so that the space around shone much more brightly than the rest of the sky. And as the heavens were serene and appeared very dark, there seemed to be a gap in this part, through which a view was disclosed of brighter heavens beyond. All this I have continued to see up to the present time [the work in which these remarks appear-the Systema Satumium-was published in 1659], so that this singular object, whatever it is, may be inferred to remain constantly in that part of the sky. I certainly have never seen anything resembling it in any other of the fixed stars. For other objects once thought to be nebulous, and the Milky Way itself, show no mistiness when looked at through telescopes, nor are they anything but congeries of stars thickly clustered together.'

Huyghens does not seem to have noticed that the space between the three stars he described as close together is perfectly free from nebulous light - insomuch that if the nebula itself is rightly compared to a gap in the darker heavens, this spot resembles a gap within the nebula. And indeed, it is not uninteresting to notice how comparatively inefficient was Huyghens' telescope, though it was nearly eight yards in focal length. A good achromatic telescope two feet long would reveal more than Huyghens was able to detect with his unwieldy instrument.

The Orion Nebula (M 42) by Messier 1773



M. le Gentil also examined this nebula with ordinary refractors …There is a joint of the drawings which he had made of it at that time, as well as those of Huygens & of Picard; these drawings differ from each other, so that one may suspect that this nebula is subject to sort of variations.

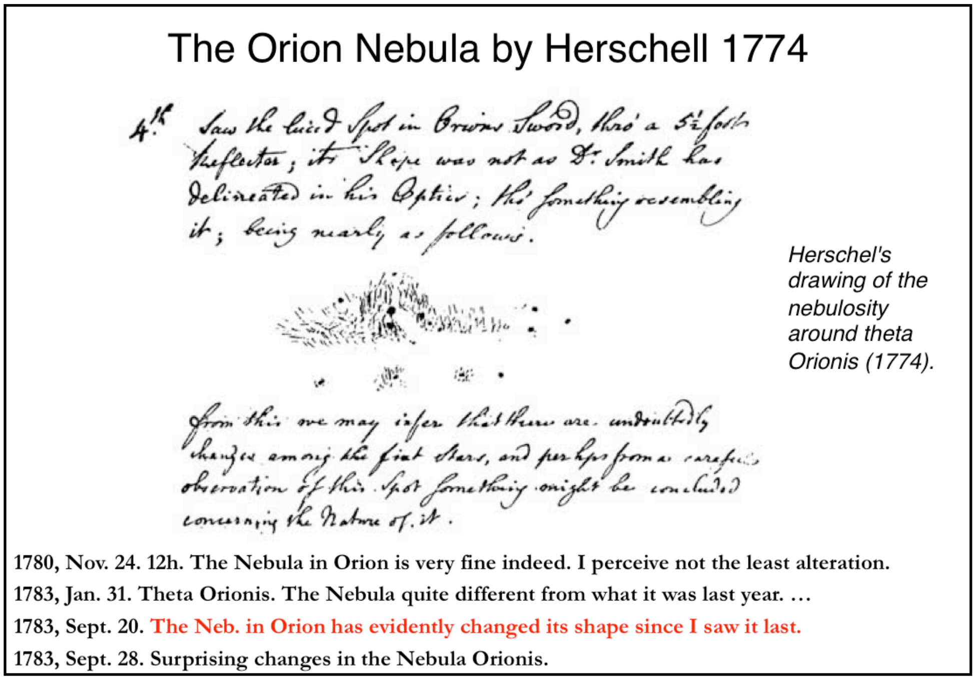
…

The drawing of the nebula in Orion, which I present at the Academy, has been traced with the greatest care which is possible for me.

It is somewhat unusual that the Orion Nebula has found its way into Messier's list, together with the bright star clusters Praesepe M44 and the Pleiades M45; Charles Messier usually only included fainter objects which could be easily taken for comets. But in this one night of March 4, 1769, he determined the positions of these wellknown objects, (to say it with Owen Gingerich) `evidently adding these as "frosting" to bring the list to 45', for its first publication in the *Memoires de l'Academie* for 1771 (published 1774).

One may speculate why he prefered a list of 45 entries over one with 41; a possible reason may be that he wanted to beat Lacaille's 1755 catalog of southern objects, which had 42 entries. Messier measured an extra position for a smaller northeastern portion, reported by Jean-Jacques d'Ortous de Mairan previously in 1731 as a separate nebula, which therefore since has the extra Messier number: M43.

As the drawings of the Orion Nebula known to him did so poorly represent Messier's impression, he created a fine drawing of this Object, in order to "help to recognize it again, provided that it is not subject to change with time" (as Messier states in the introduction to his catalog).



excerpts from
the scientific papers on
"The Construction of the Heavens"
by William Herschel (1738-1822)
Their situation and shape, as well as condition, seems to denote the greatest variety imaginable. In another stratum, or perhaps a different branch of the former, I have seen double and treble nebulæ, variously arranged; large ones with small, seeming attendants; narrow but much extended, lucid nebulæ or bright dashes; some of the shape of a fan, resembling an electric brush, issuing from a lucid point; others of the cometic shape, with a seeming nucleus in the center; or like cloudy stars, surrounded with a nebulous atmosphere; a different sort again contain a nebulosity of the milky kind, like that wonderful, inexplicable phænomenon about theta Orionis; while others shine with a fainter, mottled kind of light, which denotes their being resolvable into stars....

Proctor says: In the year 1811, Sir W. Herschel announced that he had (as he supposed) detected changes in the Orion nebula. The announcement appeared in connection with a very remarkable theory respecting nebulas generally-Herschel's celebrated hypothesis of the conversion of some nebulas into stars. The astronomical world now heard for the first time of that self-luminous nebulous matter, distributed in a highly attenuated form throughout the celestial regions, which Herschel looked upon as the material from which the stars have been originally formed…. Few theories have met with a stranger fate. Received respectfully at first on the authority of the great astronomer who propounded it-then in the zenith of his fame-the theory gradually found a place in nearly all astronomical works. But, in the words of a distinguished living astronomer, 'The bold hypothesis did not receive that confirmation from the labours of subsequent inquirers which is so remarkable in the case of many of Herschel's other speculations.'

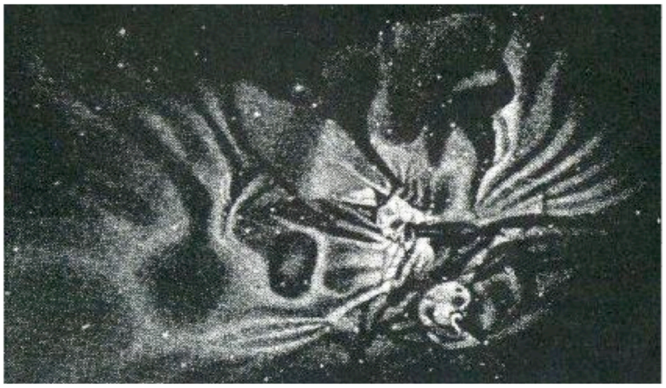
William Lassell painting of Orion Nebula (1842)

Orion Nebula painting, from observations made at Valletta, Malta, with the Twenty-foot equatorial.

... In order to perpetuate as far as possible the results of these observations, I send herewith a painting in oil of this nebula, on the same scale as my original drawings, the acceptance of which I beg from the Astronomical Society. It is the work of my friend Mr. Hippisley, executed under my own superintendence and carefully compared with my original sketches. I consider it a very faithful picture of what I saw....

William Lassell FRS (18 June 1799 – 5 October 1880) was an English merchant and astronomer.
Born in Bolton and educated in Rochdale after the death of his father, he was apprenticed from 1814 to 1821 to a merchant in Liverpool. He then made his fortune as a beer brewer, which enabled him to indulge his interest in astronomy. He built an observatory at Starfield near Liverpool with a 24-inch (610 mm) reflector telescope, for which he pioneered the use of an equatorial mount for easy tracking of objects as the earth rotates. He ground and polished the mirror himself, using equipment he constructed. The observatory was later (1854) moved further out of Liverpool to Bradstones.
In 1846 Lassell discovered Triton, the largest moon of Neptune, just 17 days after the discovery of Neptune itself by German astronomer Johann Gottfried Galle. In 1848 he independently co-discovered Hyperion, a moon of Saturn. In 1851 he discovered Ariel and Umbriel, two moons of Uranus.
When Queen Victoria visited Liverpool in 1851, Lassell was the only local she specifically requested to meet.
In 1855, he built a 48-inch (1,200 mm) telescope, which he installed in Malta because of the better observing conditions compared to England.

Lord Rosse drawing of the Orion Nebula (1850)



Lord Rosse built the world's largest (1.8m) telescope in 1845 and it remained the world's largest for the rest of the century.

Rosse claimed to resolve the Orion nebula into its individual stars.

William Parsons, 3rd Earl of Rosse, Knight of the Order of St Patrick (KP) (17 June 1800 – 31 October 1867) was a British astronomer who had several telescopes built. His 72-inch telescope "Leviathan", built 1845, was the world's largest telescope until the early 20th century.

During the 1840s, he had the Leviathan of Parsonstown built, a 72-inch (6 feet/1.83 m) telescope at Birr Castle, Parsonstown, County Offaly. The 72-inch (1.8 m) telescope replaced a 36-inch (910 mm) telescope that he had built previously. He had to invent many of the techniques he used for constructing the Leviathan, both because its size was without precedent and because earlier telescope builders had guarded their secrets or had simply failed to publish their methods. Rosse's telescope was considered a marvelous technical and architectural achievement, and images of it were circulated widely within the British commonwealth. Building of the Leviathan began in 1845 and it was first used in 1847. It was the world's largest telescope until the early 20th century

Rosse himself did not believe that nebulas were truly gaseous, but rather that they were made of such an amount of fine stars that most telescopes could not resolve them individually (that is, he considered nebulas to be stellar in nature). Rosse and his technicians claimed to resolve the Orion nebula into its individual stars, which would have cosmological and even philosophical implications, as at the time there was considerable debate over whether or not the universe was "evolved" (in a pre-Darwinian sense), a concept with which Rosse disagreed strongly. Rosse's primary opponent in this was John Herschel, who used his own instruments to claim that the Orion nebula was a "true" nebula, and discounted Rosse's instruments as flawed (a criticism Rosse returned about Herschel's own).

George Bond drawing of the Orion Nebula (1865)

George Bond (Harvard college Observatory) described the area around the Trapezium as composed of "wreaths or streaks of nebulosity", "in many instances the wreaths, like smoke from wet weeds, grass, or hay thrown on coals, seem to intertwine in a way that is quite difficult to draw".

http://ejamison.net/bond.html

George Phillips Bond (1825-1865), second director of Harvard College Observatory, whose dedication to unlocking the visual mysteries of the Orion nebula with the Harvard Observatory's 15-inch refractor led ultimately to his premature death.

During the winter months of 1861-1862 through 1863-1864 he pushed himself hard to observe the nebula as often as possible, sometimes when the temperatures were at or below 0 degrees. His eagerness to complete his work on the Orion Nebula lead him to observe in conditions at the observatory that were incompatible with the state of his declining health from tuberculosis. There was no money for heat for the observatory, and the rooms he worked in were often bitterly cold and draughty.

The Orion Nebula is a complex object to accurately sketch. George Phillips Bond described the area around the Trapezium as composed of "*wreaths or streaks of nebulosity*", and that "*in many instances the wreaths, like smoke from wet weeds, grass, or hay thrown on coals, seem to intertwine in a way that is quite difficult to draw".* To make as accurate and detailed sketch as possible, George Phillips Bond made many drawings, some using white pencil on black paper, others with lead pencil on white paper, or others using watercolor. Each of these sketches were revised or re-revised many times. His drawing on the nebula is considered to be the most accurate and complete ever made. In addition he also accurately catalogued over 1100 stars in terms of their brightness and position within the nebula.

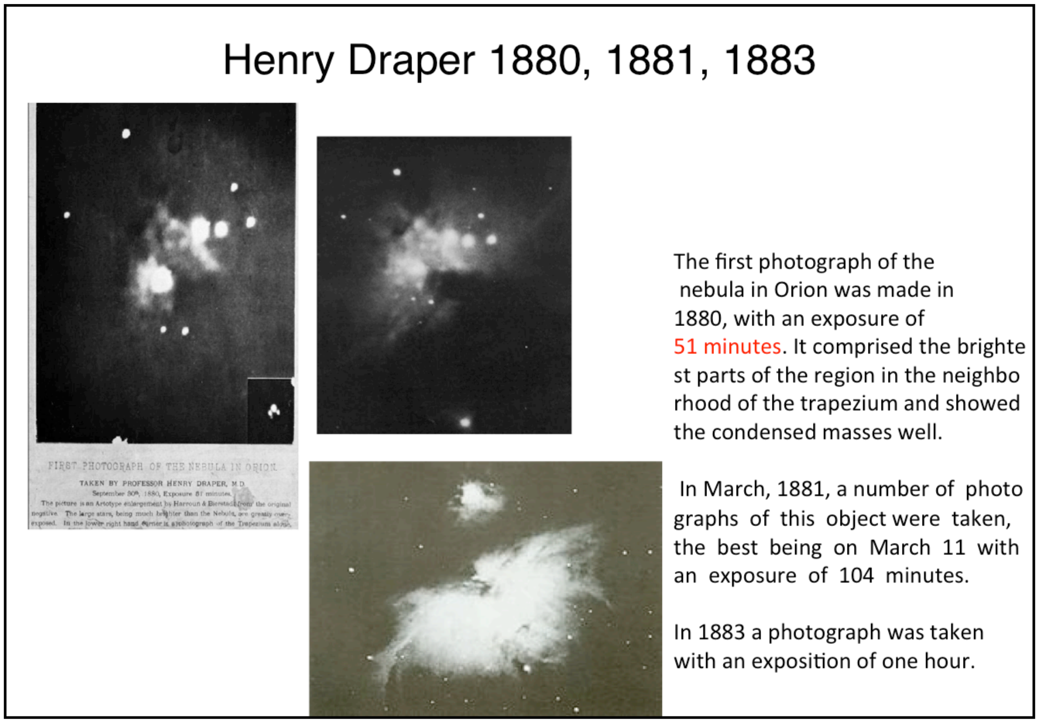
Astrophotography,, was initially started at the Harvard College Observatory by William Cranch Bond, but it was George Phillips Bond who made it a success

Etienne Trouvelot drawing of the Orion Nebula (1875)

Astrophotography did exist in the early nineteenth century, but required enormously long exposures to produce fuzzy results- so hand drawings as practiced by Trouvelot offered the clearest visions of the distant universe
Read more:
http://www.dailymail.co.uk/sciencetech/article-2085110/E-L-Trouvelot-Online-library-early-space-artist-shows-eerily-accurate-visions.html#ixzz1zwj9Cfu1

Jump to: navigation, search
Étienne Léopold Trouvelot
Étienne Trouvelot, c. 1870 Born December 26, 1827
Aisne, France Died April 22, 1895 (aged 67)
Meudon, France Nationality French Fields Astronomy
A Trouvelot lithograph depicting zodiacal light
Étienne Léopold Trouvelot (December 26, 1827–April 22, 1895) was a French artist, astronomer and amateur entomologist. He is most noted for the unfortunate introduction of the Gypsy Moth into North America.
When Joseph Winlock, the director of Harvard College Observatory, saw the quality of his illustrations, he invited Étienne onto their staff in 1872. In 1875 he was invited to the U. S. Naval Observatory to use the 26-inch refractor for a year. During the course of his life he produced about 7,000 quality astronomical illustrations. 15 of his most superb pastel illustrations were published by Charles Scribner's Sons in 1881. He was particularly interested in the Sun, and discovered "veiled spots" in 1875.
Besides his illustrations, he also published about 50 scientific papers.
By 1882, Étienne had returned to France and joined the Meudon Observatory. This was a few years before the magnitude of the problem caused by his Gypsy Moth release became apparent to the local government of Massachusetts. He died in Meudon, France.

THE FIRST PHOTOGRAPHS
OF THE ORION NEBULA



Henry Draper (March 7, 1837 – November 20, 1882) was an American doctor and amateur astronomer. He is best known today as a pioneer of astrophotography.

Henry Draper's father, John William Draper, was an accomplished doctor, chemist, botanist, and professor at New York UniversityDraper's mother was Antonia Coetana de Paiva Pereira Gardner, daughter of the personal physician to the Emperor of Brazil.

He graduated from New York University School of Medicine, at the age of 20, in 1857.[2] He worked first as a physician at Bellevue Hospital, and later as both a professor and dean of medicine at New York University (NYU). In 1867 he married Anna Mary Palmer, a wealthy socialite.

Draper was one of the pioneers of the use of astrophotography. In 1872, he took a stellar spectrum that showed absorption lines, others, such as Joseph Fraunhofer, Lewis Morris Rutherfurd and Angelo Secchi, preceded him in that ambition.

He resigned his chair in the medical department in 1873, to allow for more time for original research.

He directed an expedition to photograph the 1874 transit of Venus, and was the first to photograph the Orion Nebula, on September 30, 1880. Using his 11 inch Clark Brothers photographic refractor he took a 50 minute exposure.[1] He photographed the spectrum of Jupiter in 1880.

Draper's observatory, where he took his much-admired photographs of the moon, was located in Hastings-on-Hudson, New York, and today the building functions as the Hastings-on-Hudson Historical Society.

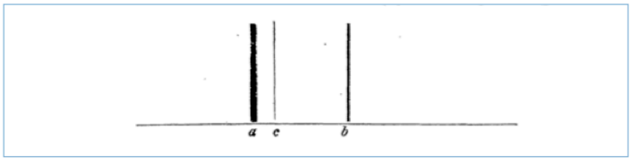
Draper received numerous awards, including honorary LL.D. law degrees from NYU and the University of Wisconsin–Madison in 1882, a Congressional medal for directing the U.S. expedition to photograph the 1874 transit of Venus, and election to both the National Academy of Sciences and the Astronomische Gesellschaft. In addition, he held memberships in the American Photographic Society, the American Philosophical Society, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science.

After his untimely early death from double pleurisy, his widow funded the Henry Draper Medal for outstanding contributions to astrophysics and a telescope, which was used to prepare the Henry Draper Catalog of stellar spectra. This historical Henry Draper's telescope is now in at the Toruń Centre for Astronomy (Nicolaus Copernicus University) at Piwnice in Poland.

THE ORION NEBULA IS MADE OF GAS !

The first spectrum of the Orion nebula

Padre Secchi (1865)



(*Translation of a Letter from the Rev. Father Secchi to Mr. De La Rue.*)

Some days ago I published in the *Journal of Rome* (20th February) my observations of the light of the Nebula of *Orion*, which is similar to that which Mr. Huggins has found for the planetary nebulæ. I do not know if Mr. Huggins has made the same observation, and yet he can hardly have omitted to study this Nebula with his powerful instrument. I will, however, mention my results; the whole spectrum of this Nebula reduces itself to three lines.

Huggins 1864
On the Spectra of some of the Nebulae

It is obvious that the nebulae … can no longer be regarded as aggregations of suns …. We have in these objects to do no longer with a special modification only of our own type of suns, but find ourselves in the presence of objects possessing a distinct and peculiar plan of structure.

In place of an incandescent solid or liquid body transmitting light of all refrangibilities through an atmosphere which intercepts by absorption a certain number of them, such as our sun appears to be, we must probably regard these objects, or at least their photo-surfaces, as enormous masses of luminous gas or vapour. For it is alone from Matter in the gaseous state that light consisting of certain definite refrangibilities only, as is the case with the light of these nebula, is known to be emitted.

First determination of the distance to the Orion cluster
1893

On a Method of estimating the Distance of certain Star-Groups with an Application to the Orion Group.

By G. F. Hardy.

On the whole, the parallax of the Orion group may be supposed with considerable probability not to differ much from 0".01. In this case the distance separating α and β would be about six million times the distance of the earth from the sun, and the intrinsic light of these stars, some thousands of times greater than the sun.

A controversy:
do the relative line intensities show spatial variation ?

Campbell 1897

Dr. Scheiner in the above mentioned article states that he has observed the spectrum of the Orion Nebula under favorable circumstances, and has found no appreciable variations.

I have thought it best to ask some of my colleagues kindly to observe the spectrum with reference to the disputed points, and their results are published herewith.

Scheiner 1897

The whole appearance recorded by Professor Campbell is nothing more nor less than the "Purkinje phenomenon."

May I be permitted to suggest that Professor Campbell might derive some advantage from the study of Physiological Optics ?[1]

William Wallace Campbell (11 April 1862 – 14 June 1938) was an American astronomer, and director of Lick Observatory from 1900 to 1930. He specialized in spectroscopy
Campbell was a pioneer of astronomical spectroscopy and catalogued the radial velocities of stars. He was made a director of Lick Observatory from 1901 to 1930. He led a team to Australia in 1922 where he photographed a solar eclipse. The data obtained provided further evidence supporting Albert Einstein's theory of relativity. In 1931 he accepted the rôle of president of the National Academy of Sciences in Washington (1931–1935).
He committed suicide in California at the age of 76.[4] He was mostly blind and suffering from bouts of aphasia. This was not only very frustrating to him, but he felt that it left him a burden to his family in terms of care and expense, according to notes he left behind at the time of his death. He had married Elizabeth Ballard Thompson in 1892; they had three sons.
Julius Scheiner (1858–1913) was a German astronomer, born in Cologne and educated at Bonn. He became assistant at the astrophysical observatory in Potsdam in 1887 and its observer in chief in 1898, three years after his appointment to the chair of astrophysics in the University of Berlin. Scheiner paid special attention to celestial photography and wrote *Die Spektralanalyse der Gestirne* (1890);

The first monochromatic photographs of Orion: Hartmann 1905

THE *ORION* NEBULA
Monochromatic Photograph with Light of Wave-Length 3727

THE *ORION* NEBULA
Photographed with Light of the Lines N_1, N_2, and $H\beta$

Taken with an objective prism to gather all the light

We should note, in the first place, the extraordinary intensity of the line λ 3727 in *all* parts of the nebula. Photograph 5 (Plate XX),

got the impression that the condensations of the nebulous mass which give the *Orion* nebula its peculiar appearance of motion are most sharply represented in the ultra-violet light, while the light from the hydrogen lines seems rather to form a uniform background.

THE ORION NEBULA VELOCITY FIELD

Spectroscopic measures

Keeler (1891)	+17.7
Wright (1901)	+16.2
Vogel (1902)	+17.4
Frost and Adams (1904)	+18.5

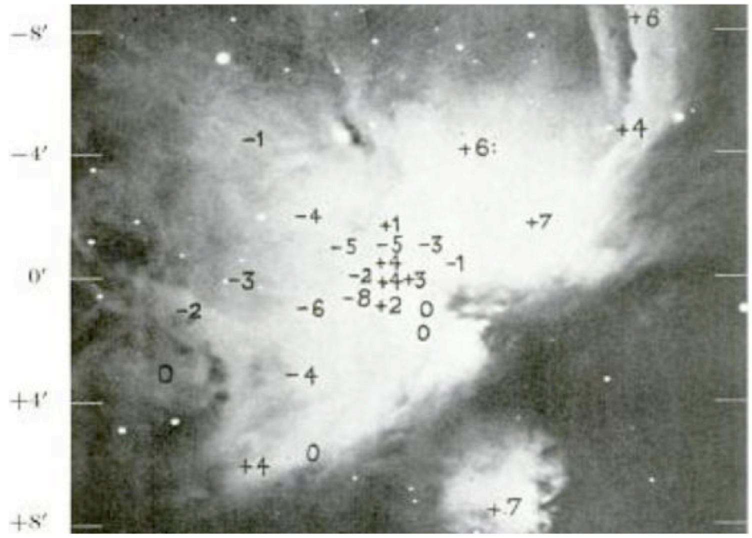
Interferometry

Buisson, Fabry, Bourget 1914

, the northeast region is withdrawing at a speed of something like 5 km per second, while the southwest region is approaching at pretty nearly the same speed. In general, the part of the nebula which we have studied has a sort of rotary movement about the line southeast-northwest, but with numerous irregularities.

Cet objet d'optique est l'interféromètre de Fabry-Pérot, du nom de ses deux inventeurs et utilisateurs, Charles Fabry et Alfred Pérot, qui furent tous deux élèves puis professeurs de physique à l'Ecole polytechnique au début de ce siècle.

Spectroscopic measures: Campbell & Moore 1918



When we consider all parts of the nebula covered by our observations, we are inclined to favor the hypothesis of great collective variations of velocity rather than a rotation as the prevailing factor

50 years of Lick observatory, 1938

FROM NEBULIUM TO OIII

Nebulium: Margaret Huggins 1898

". . . . TEACH ME HOW TO NAME THE . . . . LIGHT."

It would be a convenience if a name were chosen for the as yet undiscovered gas, which is suggested by the typical bright nebular lines, as a principal constituent of the nebulæ. Sir William Huggins has used occasionally the term *nebulum*. Independently, Miss Agnes Clerke has made the suggestion to me of *nebulium* as an appropriate term, which, "though not unobjectionable from an etymological point of view, is on all fours with *coronium*." If, however, the Greek nomenclature adopted for *helium* and *argon* is to be followed, the term *nephelium* or *nephium* may be suggested as suitable ;— for, probably, *asterium* would be thought too general in its meaning. It is most desirable that the name chosen should be one universally acceptable to astrophysicists, and so exclusively adopted. Hence, this note.

MARGARET L. HUGGINS.

ir **William Huggins**, OM, KCB, FRS (7 February 1824 – 12 May 1910) was an English astronomer best known for his pioneering work in astronomical spectroscopy

William Huggins was born at Cornhill, Middlesex in 1824. He married Margaret Lindsay, daughter of John Murray of Dublin, who also had an interest in astronomy and scientific research.[1] She encouraged her husband's photography and helped to systemise their research.
Huggins built a private observatory at 90 Upper Tulse Hill, South London from where he and his wife carried out extensive observations of the spectral emission lines and absorption lines of various celestial objects. On August 29, 1864, Huggins was the first to take the spectrum of a planetary nebula when he analyzed NGC 6543.[2] He was also the first to distinguish between nebulae and galaxies by showing that some (like the Orion Nebula) had pure emission spectra characteristic of gas, while others like the Andromeda Galaxy had spectra characteristic of stars. Huggins was assisted in the analysis of spectra by his neighbour, the chemist William Allen Miller. Huggins was also the first to adopt dry plate photography in imaging astronomical objects.[1]

Moore 1926

Spectroscopic data indicate a low atomic weight for nebulium. There is, however, no place for such a new element, since the sequence of atomic numbers is unbroken from hydrogen up to elements of high atomic weight. Hence there is reason for believing that the source of the two radiations in question is to be ascribed to the excitation of one or more of the known elements under conditions which so far have not been realized in the laboratory.

Bowen 1928, quoting Russell 1927

All these considerations lead to the conclusion, expressed by H.N. Russell, that « it is now pratically certain that they must be due not to atoms of unknown kinds but to atoms of known kinds shining under unfamiliar conditions ». This unfamiliar condition Russell suggests to be low density.

Ira Sprague Bowen (December 21, 1898 – February 6, 1973) was an American astronomer.

Bowen 1928

One type of line which would be possible only of conditions of very low density, is that produced by an electron jump from a metastable state.

…

In the nebulae, where the mean time between impacts is estimated at from 10^4 to 10^7 seconds, such atoms will return spontaneously and radiate a line

…

Since the probability of emission of these lines is very small, the probability of their absorption must also be very small.

NB: Bowen's paper also explains in detail the **physics of nebulae** and their **ionization structure**

Bowen's paper also explains the physics of nebulae and the successive shells of different ions

THE CHEMICAL COMPOSITION OF THE ORION NEBULA

Bowen & Wyse 1939

Formulated the method to determine abundances in ionized nebulae
and applied if to NGC 7027

Wyse 1942

applies a differential method starting from NGC 7027
to derive the chemical composition in 9 planetary nebulae
and in the Orion nebula

The similarity in chemical composition between the Orion nebula and the planetaries is interesting. While little is known of the origin of the planetary nebulae, it seems likely that they consist of matter that has been thrown off from the central stars. The diffuse nebulae, on the other hand, as typified by the Great Nebula in Orion, have presumably never been in the form of stars. One might therefore expect to find significant differences in chemical composition between the two kinds of objects, especially so in the light of Bethe's[16] studies of the sources of energy in stellar interiors. If the foregoing assumptions are all taken at their face-value, the similarity in chemical composition indicated by the present investigation would appear to imply that the material constituting the planetary nebulae has been affected only slightly, if at all, by the transmutation of elements in the deep interior of the central stars. Such a conclusion is, of course, only tentative, and further study of the problem would be desirable.

But the derived abundances were crude because the importance of the electron temperature was not fully recognized

Arthur Bambridge Wyse: Lick Observatory

1909-1942 Assistant Astronomer in the Lick Observatory On the night of June 8, 1942, there occurred a disastrous accident over the Atlantic Ocean, off the New Jersey coast. Two lighter-than-air Navy craft collided during an experimental operation in which they were jointly engaged, and the occupants of both vessels, thirteen in number, were, with a single exception, lost. Besides the crews, there were aboard five scientists, all of whom perished, among them, Arthur Wyse. In this swift tragedy the University of California lost a useful and promising member of its faculty. Dr. Wyse was at the time on leave of absence from the University in engagement upon technical developments relating to the war.
Arthur Bambridge Wyse was born at Blairstown, Iowa, June 25, 1909. Entering the College of Wooster in Ohio, at the age of sixteen, he attracted the attention of his instructors as an outstanding student, not only of the classics but also of the physical sciences to which his interest was directed in the later years of the course.
Among his principal interests were the eclipsing variable stars
While Wyse's field of research was principally observational astronomy, his interest in problems of a theoretical character, and his skill in the mathematical treatment of them, were turned to advantage in investigations which, more often than not, were undertaken in aid of his colleagues at the Observatory. One such inquiry related to the distribution of material in spiral nebulae, another to the rate of fading of the disk of a star from the center toward the edge. His demonstrated ability to work to advantage in many fields is to be ascribed to the breadth of his vision, the clarity of his mind, and his ability to recognize quickly the fundamental principles of a problem.

Aller & Liller 1959

Perform the first thorough determination of the chemical abundances in the Orion nebula, based on a spectrum ranging from 3700 to 1100A.

An estimate of the relative atomic abundances shows that the chemical composition of the nebula is the same as that of the involved stars, thus providing a useful check on the method of analysis.

THE TEMPERATURE OF THE ORION NEBULA

Aller 1946: T_e from [OIII]

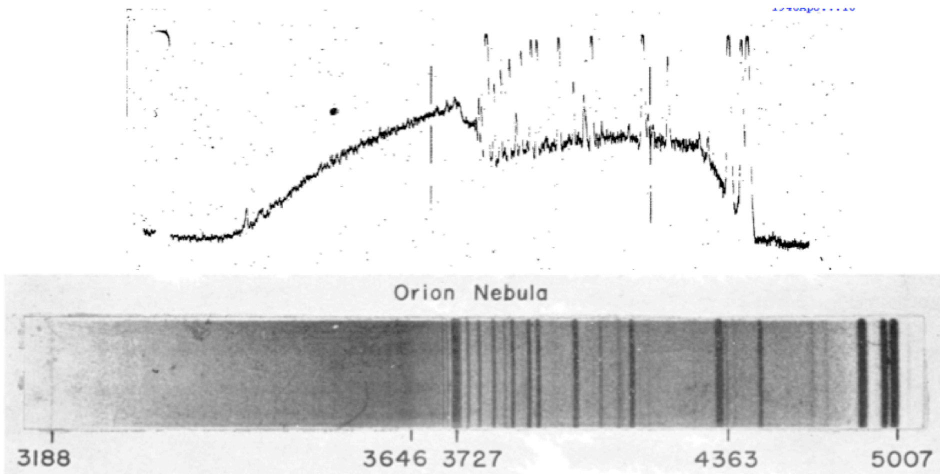
$$\frac{I(\mathrm{N1}+\mathrm{N2})}{I(\lambda\,4363)} \sim 5e^{\frac{33{,}000}{T_e}}$$

whence we find, $T_e \sim$ 10,500°K .

Lawrence Hugh Aller (September 24, 1913 – March 16, 2003) was an American astronomer. He was born in Tacoma, Washington. He never finished high school and worked for a time as a gold miner. He received his bachelor's degree from the University of California, Berkeley in 1936 and went to graduate school at Harvard in 1937. There he obtained his master's degree in 1938 and his Ph.D. in 1943. From 1943 to 1945 he worked on the Manhattan Project at the University of California Radiation Laboratory. He was an assistant professor at Indiana University from 1945 to 1948 and then an associate professor and professor at the University of Michigan until 1962. He moved to UCLA in 1962 and helped build its astronomy department. He was chair of the department from 1963 to 1968.[1]

His work concentrated on the chemical composition of stars and nebulae. He was one of the first astronomers to argue that some differences in stellar and nebular spectra were caused by differences in their chemical composition. Aller wrote a number of books, including *Atoms, Stars, and Nebulae*,

Greenstein 1946: T_e from Balmer continuum



$T_e = 12{,}000K$

Jesse Leonard Greenstein (October 15, 1909 – October 21, 2002) was an American astronomer.
He earned a Ph.D from Harvard University in 1937. Before leaving Harvard, Greenstein was involved in a project with Fred Lawrence Whipple to explain Karl Jansky's discovery of radio waves from the Milky Way and to propose a source.[1] He began his professional career at Yerkes Observatory under Otto Struve and later went to Caltech. With Louis G. Henyey he invented a new spectrograph and a wide-field camera. He directed the Caltech astronomy program until 1972 and later did classified work on military reconnaissance satellites.
With Leverett Davis, Jr, he demonstrated in 1949 that the magnetic field in our galaxy is aligned with the spiral arms. His theoretical work, with Davis, was based the conclusion just reached by William A. Hiltner that the recently detected polarization of starlight was due to scattering off interstellar dust grains aligned by a magnetic field.
Greenstein did important work in determining the abundances of the elements in stars, and was, with Maarten Schmidt, the first to recognize quasars as compact, very distant sources as bright as a galaxy. The spectra of the first quasars discovered, radio sources 3C 48 and 3C 273, were displaced so far to the red due to their redshifts as to be almost unrecognizable, but Greenstein deciphered 3C 48 shortly before Schmidt, his colleague at the Hale Observatories worked out the spectrum of 3C 273.

Temperature fluctuations: Peimbert 1967

Differences between temperatures in different zones of HII regions are expected and lead to differences between temperatures determined by various methods

Region	$T_{(4363/5007)}$ (°K)	$T_{(3727/7325)}$, $_{(5755/6584)}$ (°K)	$T_{(Bac/H\beta)}$ (°K)
Ori I	8900 ± 300	13700 ± 800	7100^{+1600}_{-1200}
Ori II	9450 ± 300	12400 ± 800	6500^{+1500}_{-1100}
Ori III	9450 ± 300	10500 ± 800	6100^{+1400}_{-1000}

A method is proposed to derive the mean temperature T_0 and its fluctuation t^2 in real nebulae

Peimbert & Costero 1969

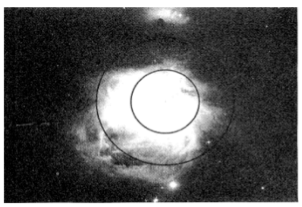
Emphasize the bias in the derived abundances if temperature fluctuations are not considered and propose a method to account for them

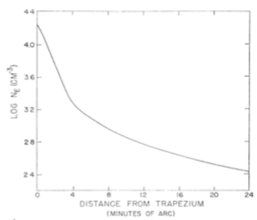
THE ORION NEBULA
AND THE STRÖMGREN SPHERE

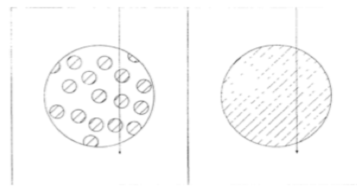
Greenstein 1946

Investigates the continuumof the Orion nebula within the framework of the Strömgren sphere

Osterbrock & Flather 1959

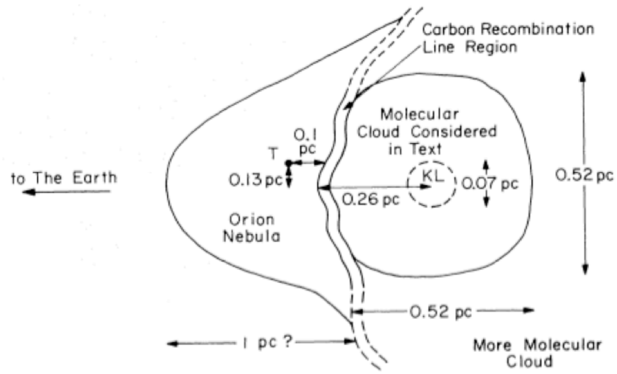






Use a spherical approximation to infer that gas is distributed in condensations occupying 1/30 of the total volume. This is the birth of the concept of volume filling factor

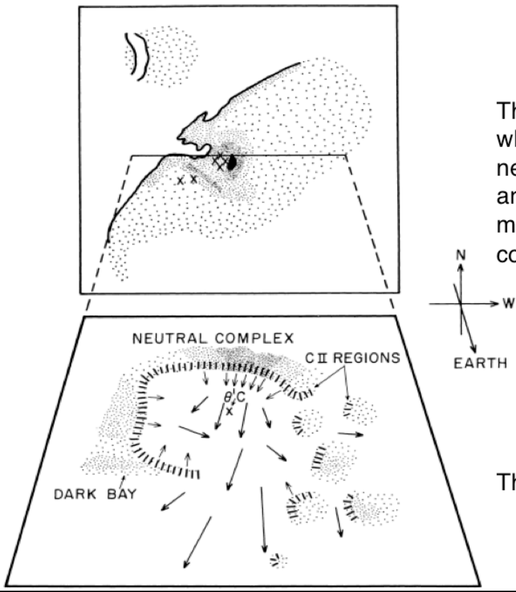
Zuckerman 1973



The Orion Nebula is a protrusion off the front edge of the dense molecular cloud whose central condensation is the Kleinmann-Low nebula.
The present model eliminates the two major difficulties associated with previous models in which the Trapezium is located at the center of an expanding cloud.

Wilson's expansion model encountered two difficulties:
The observed radial velocities could not be easily related to spherical expansion
And th eexpected redshifted component was not observed from th eback half of the nebula

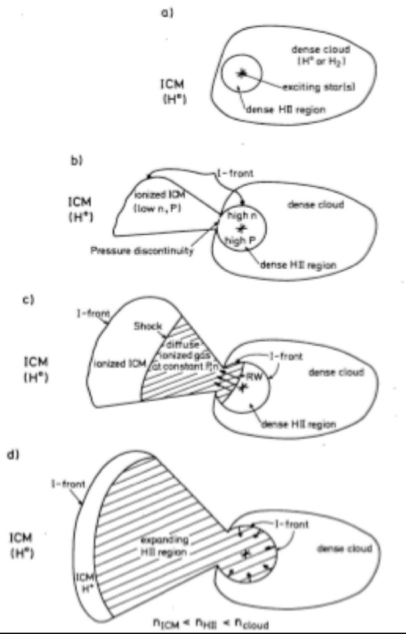
Balick, Gammon & Hjellming 1974



The nebular model is a highly dynamic one where newly ionized gas flows into the nebular core from the nearby neutral gas, and then disperses into the lower density medium on the near side of the neutral complex.

This became known as the blister model

Tenorio-Tagle 1979



Presents a numerical model of the evolution of HII regions, when star formation occurs inside a dense cloud, near its border.

Accounts for the velocity field and large scale density variations observed in some HII regions.

This is the champagne model

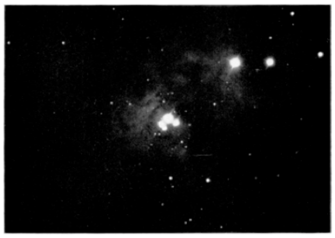
The Orion Nebula by Malin 1979

Top left is NE. Image width is about 32 arc min
Image and text © 1979-2010, Australian Astronomical Observatory, photograph by David Malin.
The Orion Nebula is famous for a number of reasons. It is the nearest bright nebula to us and can be seen with the naked eye. Its brightness led to it being the first nebula ever photographed (in 1882) and its proximity (1350 light years) means that we know more about it than any other star-forming region. It is also in a very active stage of star formation and it is perfectly placed for us to explore the intimate details of the birth of stars.

The inner regions are glowing mainly in the red light of excited hydrogen, which together with some green emission from oxygen give the centre of the nebula a yellowish colour. The energy for this spectacular display comes from the small cluster of stars in the brightest part of the nebula. Three, five-minute exposures were used to make this picture using glass plates sensitive to blue, red and green light, taken with the Anglo-Australian Telescope. A series of unsharp masks (one for each plate) was used during the copying stage, to produce three black and white film positives. The colour image above was made from these derivatives using an additive process in the darkroom.

DUST IN THE ORION NEBULA

Baade Minkowski 1937

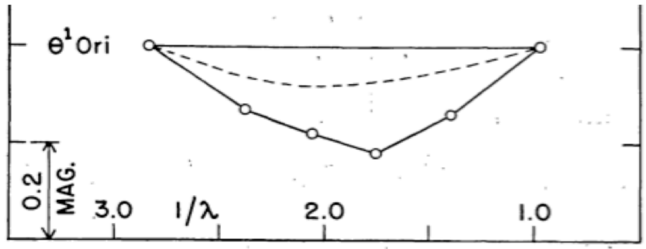


In the green (5050-5800A) image only the trapezium stars are seen

While in the red one (8300-9300A) many fainter stars are seen.

The opacity of the nebula is severely reduced in the vicinity of the Trapezium stars

Stebbins & Whitford 1945



Open circles: Deviation from normal law of reddening (dashed line) for OrionB stars

Perform multicolor photometry of 238 stars and find that the extinction law is universal except for the Orion Trapezium cluster

O'Dell Hubbard 1965

Perform a careful study of the continuum (emission from H and He in the nebular gas and stellar light scattered bu dust particles) in different zones of the Orion nebula.

Conclude that the gas-to-dust ratio increases sharply in the outer regions, which they relate to the existence of the abnormal extinction law in Orion

Zoom into the Orion Nebula

Credit: NASA, ESA, and G. Bacon (STScI)