

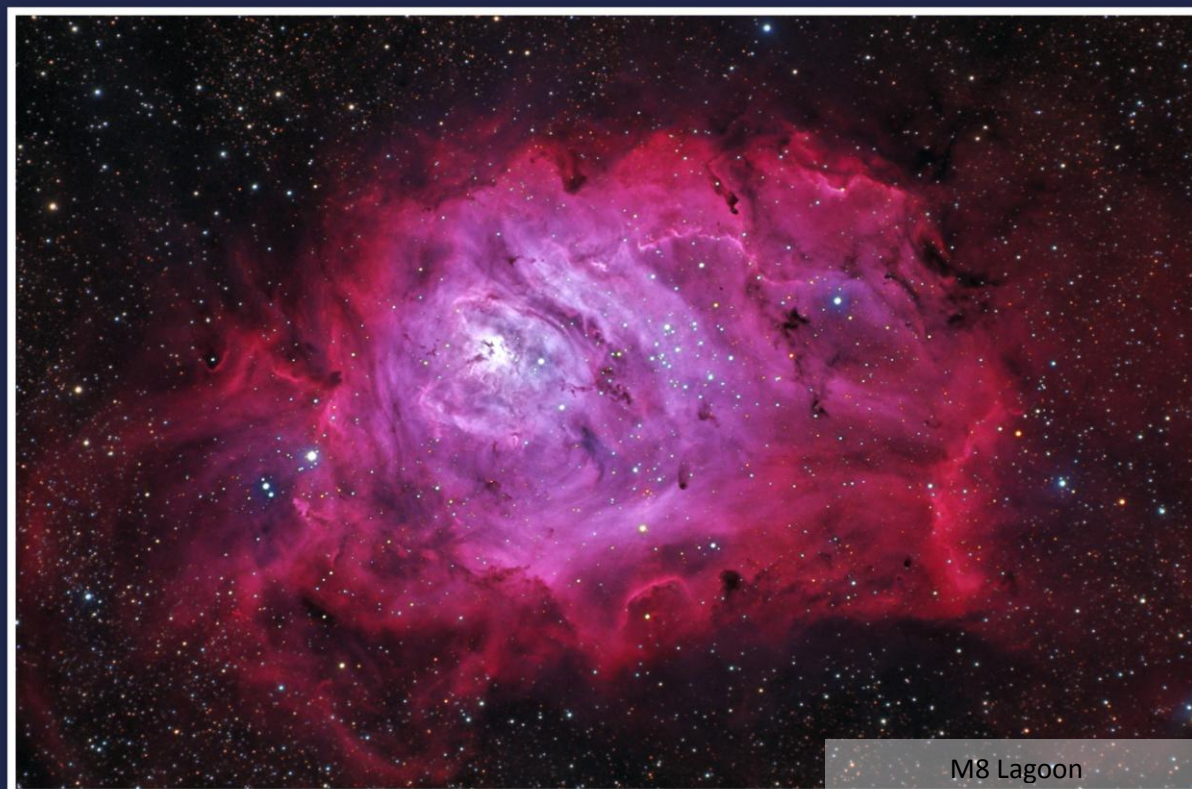
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# Nebulae

The Lagoon and Dumbbell Nebulae



M27 Dumbbell



M8 Lagoon

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## Content:

Introduction .....	2
History of nebulae .....	3
How are nebulae formed? .....	3
Types of nebulae .....	3
Diffuse nebulae.....	4
Emission Nebulae .....	4
Reflection Nebulae.....	4
Dark nebulae .....	4
Planetary Nebulae .....	5
Protoplanetary nebulae.....	5
Interaction between the stars' emission and the interstellar medium .....	5
Interstellar extinction.....	5
Interstellar reddening.....	6
Summer astronomical school, July 2014.....	7
M8 – The Lagoon Nebula .....	9
M27 – The Dumbbell Nebula .....	11
M42 – The Orion Nebula: photography.....	12
Conclusion.....	13
Sources .....	13

# Introduction

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In the space between the stars (also called interstellar medium) there is interstellar matter with different density. On some places, clouds of dust, hydrogen and plasma are being formed. They can be seen under certain circumstances. These objects are called nebulae.

Nebulae are interstellar clouds of dust, gas and plasma. They could be seen due to the emitted and absorbed waves and particles, which distinguish the nebula from the interstellar medium.

The nebulae often have star-forming regions, such as the Eagle nebula. Part of this nebula is shown in one of the most famous NASA photos - Pillars of Creation. In these regions, gas and dust gather together to form bigger and bigger volumes of matter. After reaching a crucial point, the mass of the matter is enough to form a star. The remaining matter is supposed to form planets and other planetary objects (moons, asteroids, comets, etc.).



**Pillars of Creation**

# History of nebulae

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At first all luminous, wide and stationary astronomic objects, about which it was known that they are not stars, were called "nebulae", including star clusters and galaxies.

In the second half of XVIII century Charles Messier started describing the objects he observed and gave them numbers. This way he created the first catalogue which includes real nebulae as well as some stars, clusters and galaxies. The first version of the catalogue had 45 objects. Today their number is 110.

Messier lived and worked in France, which means that his catalogue contains objects from the north celestial pole and celestial latitude of about 35°. All the objects could be observed in a cloudless night in the early spring. That's when Messier marathons are organized.

With the development of astronomy and improvement of the telescopes, the term for nebulae has become more precise. Some "nebulae" have turned out to be star clusters or galaxies (Edwin Hubble discovered the galaxies in 1924). The dark nebulae are also discovered later.

## How are nebulae formed?

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There are different ways a nebula could be formed. Most of the nebulae form as a result of the gravitational collapse of gases in the interstellar medium. The matter collapses under its own weight and big stars are born. The UV light they emit ionizes the surrounding gases and creates plasma. Other way of forming nebulae is from supernovas. The released matter is being ionized by the energy of the explosion. Planetary nebulae are the final stage of evolution of the stars with small mass.

## Types of nebulae

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Nebulae are classified based on two of their features. The first one is whether they emit or absorb light. They're called light and dark nebulae. The second feature is the contents of the nebula.

The light nebulae are seen due to emitted or reflected light. The energy sources can be different, based on their origin. Dark nebulae don't emit light but can be seen in the background of light nebulae.

Based on their contents the nebulae divide into gas nebulae and dust nebulae. This division is conditional because every nebula contains both gas and dust.

Nebulae can be divided as follows:

1. Diffuse
  - Emission
  - Reflection
  - Dark
2. Planetary
3. Protoplanetary

## 1. Diffuse nebulae

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They are extensive and don't have accurate boundaries. When there is a light source, they can be separated in two types - emission or reflection, depending on the light source.

- *Emission nebulae*

Emission nebulae are clouds of high temperature gas. The gas glows because of the UV energy. Those nebulae could reach tens of parsecs of diameter. They expand under the influence of the hot gases. If during its expansion the nebula encounters dense interstellar gas and dust regions, there is a possibility of forming dense clouds.

- *Reflection nebulae*

Reflection nebulae reflect the light of nearby stars. They are small in size and less bright in comparison to emission nebulae. They have about 10 times less luminosity than the actual stars. They could also be observed near emission nebulae, whose light they reflect.

- *Dark nebulae*

Dark nebulae block light because of their high density. They can be seen on the background of the Milky Way or other nebulae.

## 2. Planetary Nebulae

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Planetary nebulae are formed from exploded stars with small masses. They are smaller than diffuse nebulae, but have higher density. Despite their name they are not related to planets but just mistaken for being ones. Their mass is even smaller than the mass of the Sun. They are named after their form such as Owl, Dumbbell, Saturn, etc.

## 3. Protoplanetary nebulae

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Protoplanetary nebulae are planetary nebulae in earlier stage of their evolution. They emit infrared radiation just like reflection nebulae. As their temperature increases they slowly become planetary nebulae.

# Interaction between the stars' emission and the interstellar medium

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- *Interstellar extinction*

Interstellar extinction is the absorption of the light by interstellar dust and gas, which is positioned on the visible way of the nebula (between the object and the observer). That kind of regions look as if they are empty spaces on the sky. A long time ago, people thought that these are just areas without stars.

The first person who tried to measure the interstellar extinction was the famous russian astronomer Vasily Yakovlevich Struve (1794-1864).

The interstellar extinction is the reason why we see the stars in nebulae fainter than they actually are. It can be calculated using the following formula:

$$m = M - 5 + 5\lg(r) + A,$$

where:

**m** – apparent magnitude;

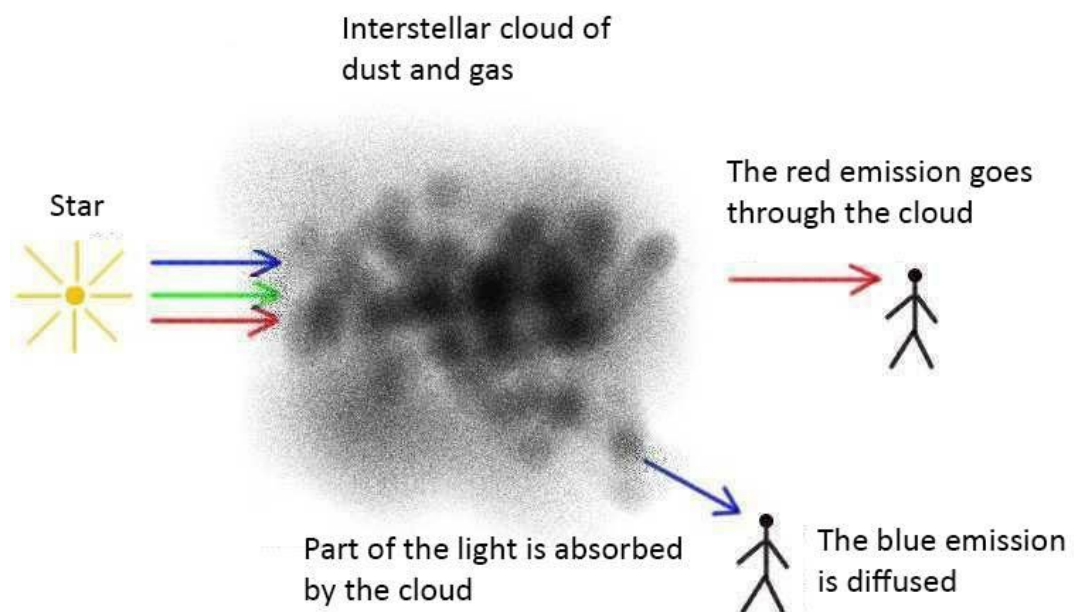
**M** – absolute magnitude;

$r$  – distance to the star;

$A$  – interstellar extinction (measured in magnitudes).

- *Interstellar reddening*

The size of the dust grains in the interstellar medium is comparable to the wavelength of blue light. As a result, the blue light coming from distant objects is strongly absorbed by the dust. This makes the objects look redder than they actually are. This is known as interstellar reddening.



# Summer astronomical school, July 2014

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As a tradition, we, the members of the Youth Astronomy Club „Sotis“ in Planetarium-Smolyan, attend a summer astronomical school in the National Astronomical Observatory „Rozhen“, where a lot of astronomers work. Everytime we go, we learn new and interesting things and we improve our skills for working with different telescopes.

In one of the nights of our expedition we organized a Messier marathon – we tried to observe as many as possible astronomical objects from the catalogue. For the observation we used the 30cm Meade telescope which is installed in the pavilion in the visitor centre in NAO “Rozhen”.

We started observing from west to east in the beginning of the astronomical night (about an hour and a half after sunset) the following objects:

- M53 in the Coma Berenices constellation;

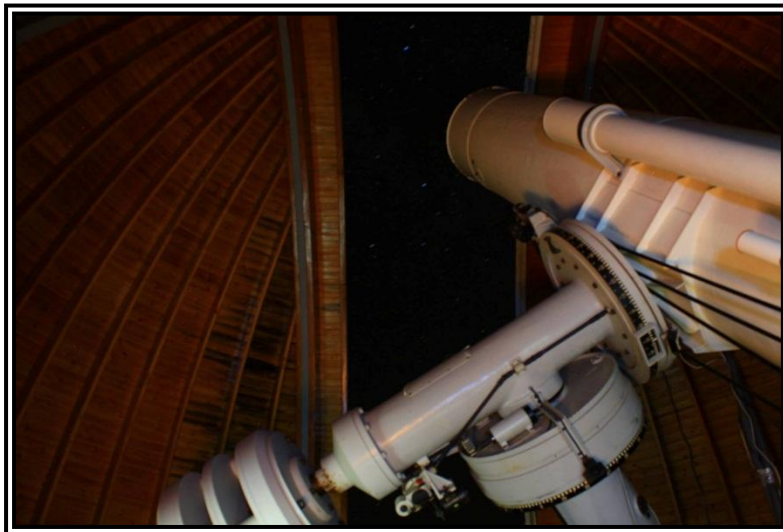


30 cm Meade telescope

- M51 in the Ursa Major constellation;
- M8 in the Sagittarius constellation;
- M13 in the Hercules constellation;
- M57 in the Lyra constellation;
- M27 in the Vulpecula constellation;
- M31 in the Andromeda constellation;
- M45 in the Taurus constellation.

We finished the Messier marathon an hour and a half before sunrise. This night we managed to learn more about each object we observed. During the summer school (it lasts one week) we had the opportunity to improve our skills for working with the Schmidt telescope. We photographed different astronomical object in the summer night sky. The two emission nebulae we observed during the Messier marathon – M8-The Lagoon Nebula and M27-The Dumbbell Nebula – are the main subjects of our project.

### ➤ The Schmidt telescope



The Schmidt telescope looking at the stars (Photo taken by Kali Hristova and Andrey Tsarev)

Diameter of the corrector plate: 50 cm;  
Diameter of the spherical mirror: 70 cm;  
Focal length: 172 cm;  
Focal ratio: F/3.44.

# M8 – The Lagoon Nebula

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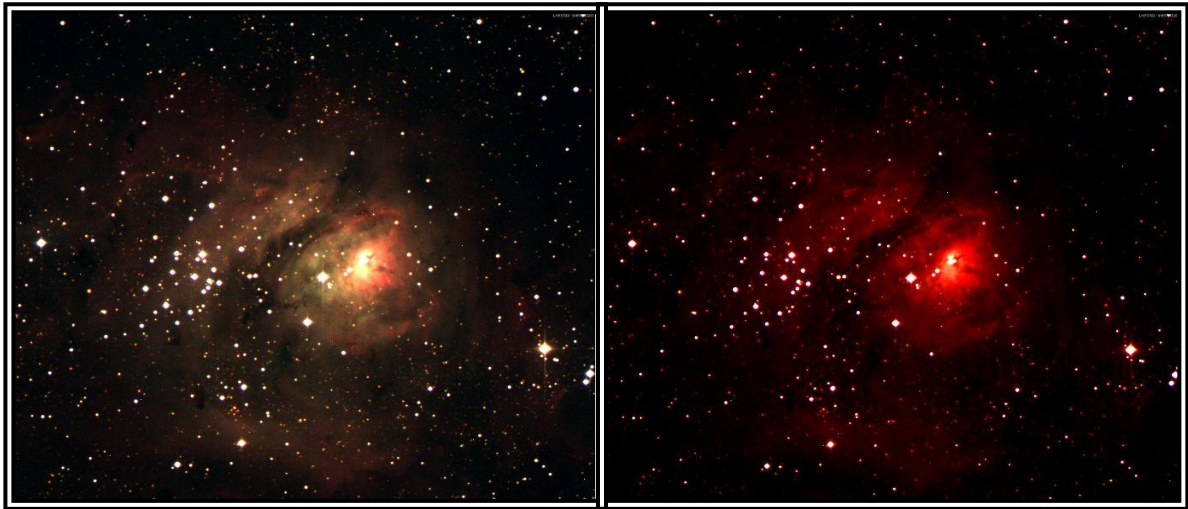


Photo of M8: The Lagoon Nebula taken with the Schmidt Telescope, Rozhen 2014  
The photos are edited with the programs Astroart and MaximDL.

The Lagoon Nebula, also known as Messier 8 (M8) or NGC 6523, is one of the brightest and most beautiful star-forming regions in the sky (it has already formed practically a brand new star cluster N6530). The nebula is a giant interstellar cloud of gas and dust that is composed mostly of hydrogen, ionized by the strong ultraviolet radiation from the two hot stars – 9 Sagittarii – with magnitude of 6 and Herschel 36 - with magnitude of 9. The ionization causes the hydrogen's glowing.

The Lagoon Nebula was first spotted by Giovanni Hodierna before 1654. In 1680 John Flamsteed observed the same object and classified it as a nebula. However, the discovery of The Lagoon Nebula is often credited to the french astronomer Legentil de La Galaisiere who observed it in 1747. In 1764 The Lagoon Nebula became also known as M8 after Messier included it in his catalogue. The name „Lagoon“ refers to the shape of the nebula and the dark curved line in its middle.

M8 is located in the Sagittarius constellation. The distance between the nebula and the Earth is estimated at 4500 – 6000 light years but according to David J. Eichler it is 5200 light years. The Lagoon Nebula covers an area of 100x50 light years in the sky and the apparent dimensions are 90x40 arc minutes.

The apparent magnitude of M8 is 6.0m. As we didn't manage to find any information about its absolute magnitude, we calculated it using the formula for the relation between the apparent and the absolute magnitude of the nebula:

$$M = m + 5 \lg 10^{r_0/r}$$

where:

- M – absolute magnitude;
- m – apparent magnitude;
- $r_0 = 10 \text{ parsecs} \approx 32.616 \text{ly}$ ;
- r – distance to Earth.( $r=5200 \text{ly}$ .)

According to our calculations  $M_{M8} \approx 9.98714m$ . Using the formula for the relation between the interstellar extinction, the apparent and the absolute magnitude of M8, we estimated the interstellar extinction is approximately  $-2.703143m$ . Therefore the brightness of the stars is  $-2.703143m$  less than what it would be if the stars weren't in the nebula.

### M8 – The Lagoon Nebula

Object Type	Emission Nebula
Constellation	Sagittarius
RA	18h 03m 37s
DEC	-24°23'12"
Distance	5200ly
Radius	55x25ly
Apparent size	90x40arc minutes
Absolute magnitude	9.98714
Apparent magnitude	6.0
Interstellar extinction	-2.703143m

# M27 – The Dumbbell Nebula

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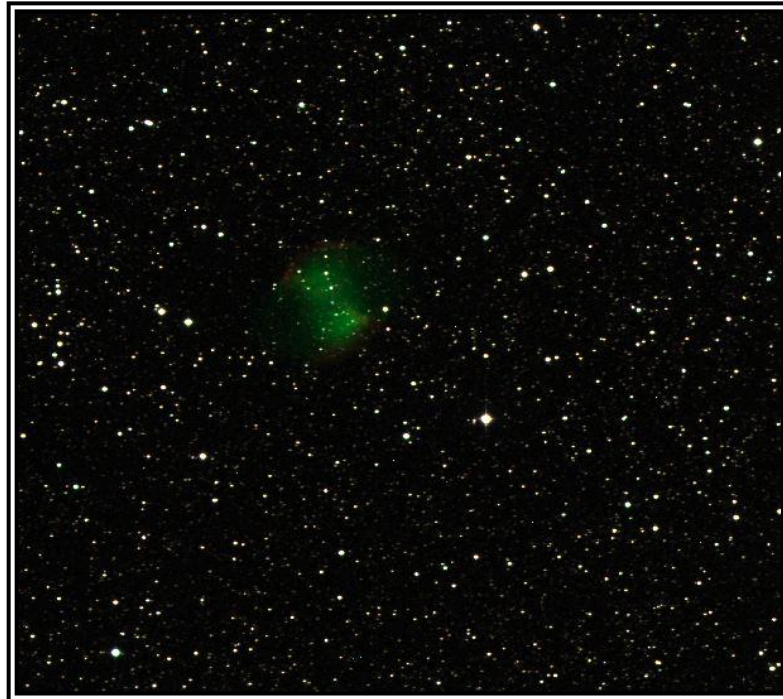


Photo of M27: The Dumbbell Nebula taken with the Schmidt Telescope, Rozhen 2014  
The photos are edited with the programs Astroart and MaximDL.

The Dumbbell Nebula, also known as M27 or NGC 6853, is the first ever found planetary nebula. It is located in the Vulpecula constellation. The nebula is a remnant of a dying star which is approximately 2 times smaller than the Sun. The star is hot and blue with temperature of 85000K (Most of these stars usually turn into red giants. They lose their mass by ejection of the outer gas layers. These layers expand in space, forming a temporary wrap around the star.).

M27 Dumbbell is found by Charles Messier on the 12 of July 1764. He describes it as a nebula without a star that has oval shape. The name comes from John Herschel, an English astronomer, who observed the nebula in 1828 and compared it to a dumbbell.

At a distance of 1360 light years the Dumbbell nebula is one of the closest planetary nebulae to us and one of the biggest. The age of M27 is between 3000 and 4000 years. The nebula is expanding with velocity of 2.3 arc minutes and 6.8 arc minutes in its centre. The lineal radius is approximately 1.44 light years. M27 could be observed with binoculars or a telescope. In clear sky it could be found with the guide of a telescope.

Using the formula relation between interstellar extinction, the apparent magnitude and the absolute magnitude, already mentioned above and the data

about M27 we calculated that the absorbed light by the nebula equals to  $-0.000518m$ . Therefore the brightness of the stars in this nebula is reduced by  $-0.000518m$ .

M27 - Dumbbell

Object Type	Planetary nebula
Constellation	Vulpecula
RA	19h 59m 36s
DEC	22° 43'16 "
Distance	1360ly
Radius	8x5.6 arc minutes
Apparent size	8x5.6
Absolute magnitude	-0.6
Apparent magnitude	7.5
Interstellar extinction	-0.000518
Note	M27 is the first planetary nebula to be discovered.

### ➤ **M42: The Orion Nebula – photography**

The photo is captured in the observatory of Planetarium - Smolyan.



Orion Nebula (M42)

It is edited by Andrey Tsarev with DeepSkyStacker. It contains 4 stacked photos made with Nikon D80. AF-SNIKKOR lens 70-100mm. All of the photos have ISO 800 and 15 sec. exposition.

# Conclusion

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Undoubtedly, nebulae are one of the most beautiful and attractive astronomical objects. The important information they contain about the formation of variety astronomical objects such as stars, comets, asteroids is what draws our attention to them. Scientist like Edwin Hubble and Charles Messier had been attracted to those diffuse objects in the night sky decades ago and due to their curiosity and desire to search and find, now we know a bit more about what the nebulae are.

During our work on the project we reached better knowledge on the available information concerning the nature of nebulae, their history, different ways of forming and classification, the interstellar extinction and reddening. We managed to calculate the interstellar extinction of M8 – The Lagoon Nebula and M27 – The Dumbbell Nebula, which are the main subjects of our work.

We sorted and structured the information according to plan we had made in advance. In that way we made the information easier for understanding. We added images, tables and lists in order to illustrate the presented information.

Our project gives the opportunity of reaching better understanding about nebulae as astronomical objects but also lets the readers sense the beauty of the night sky.

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