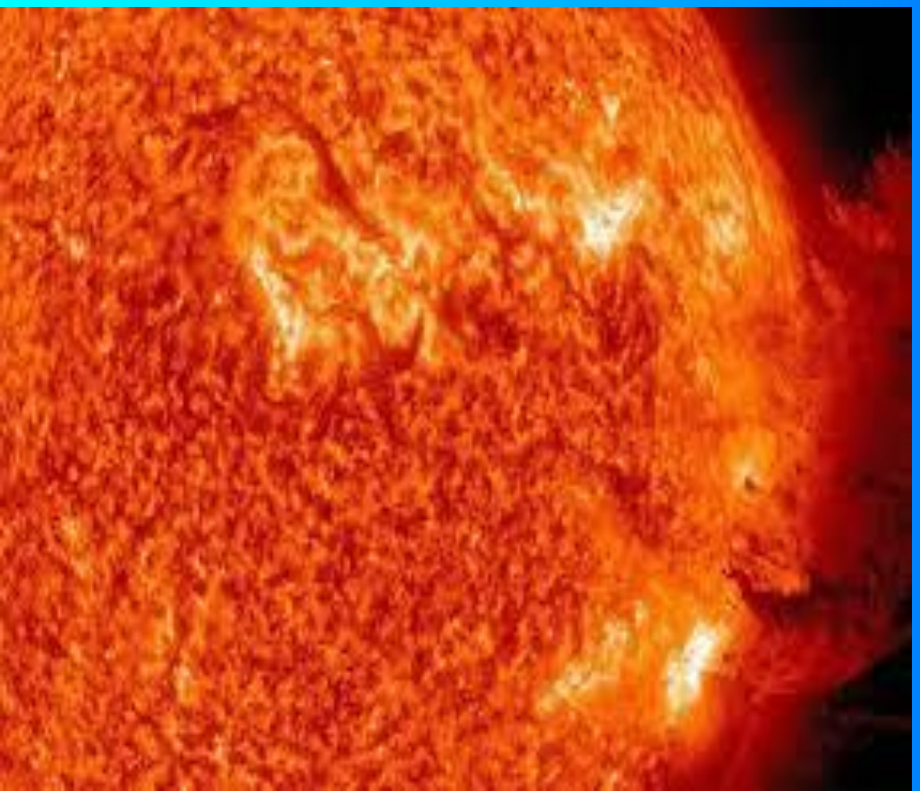
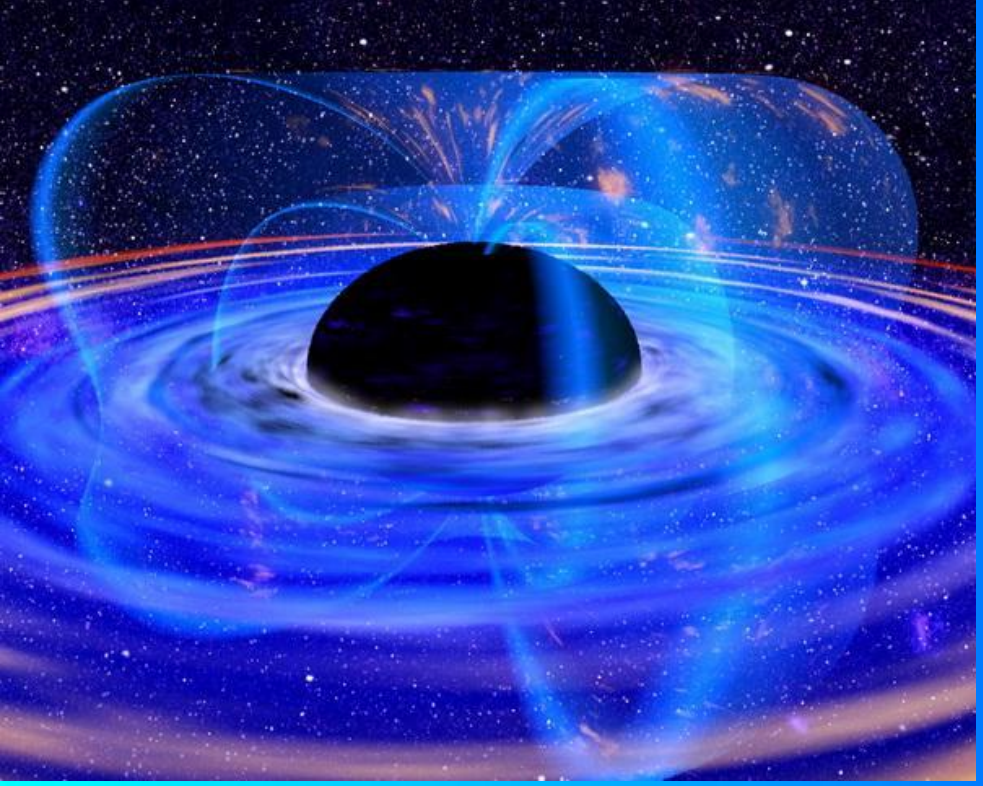
# Plasma and her properties



# Plasma

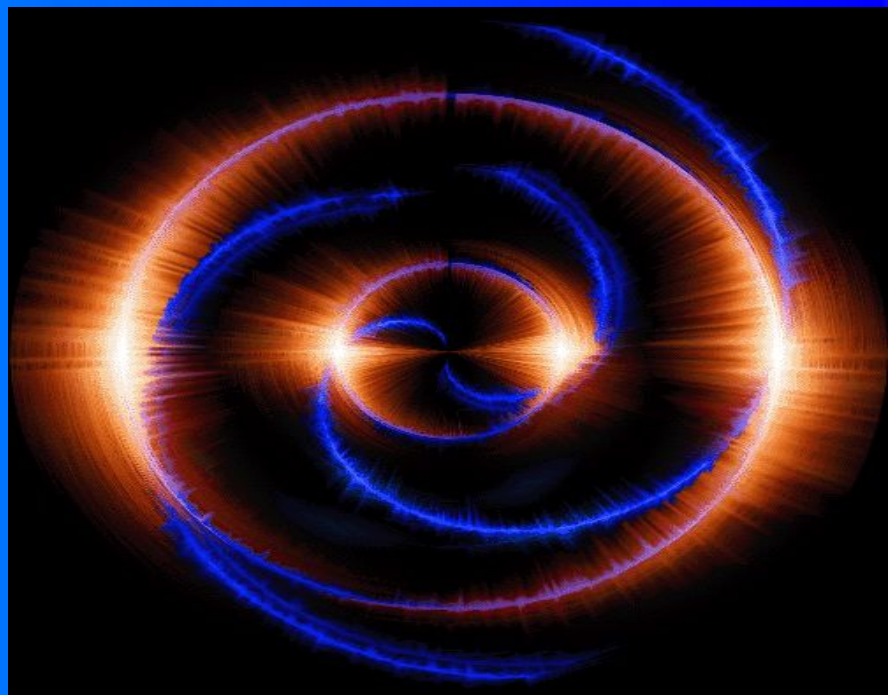
***Plasma is a partially or fully ionized gas formed from neutral atoms (or molecules) and charged particles (ions and electrons).***

***Plasma is sometimes called the fourth (after solid, liquid and gaseous) state of aggregation of matter.***

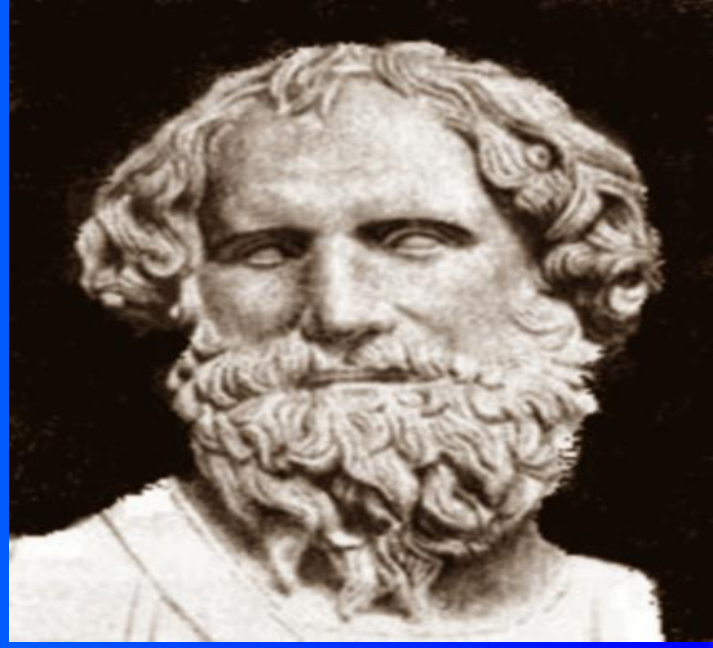


*The presence of free electric charges makes plasma a conductive medium, which causes its much greater (in comparison with other aggregate states of matter) interaction with magnetic and electric fields.*

*The fourth state of matter was discovered by W. Crookes in 1879 and named "plasma" by I. Langmuir in 1928, possibly due to its association with blood plasma.*



*The philosophers of antiquity, starting with Empedocles, argued that the world consists of four elements: earth, water, air and fire. This position, taking into account some assumptions, fits into the modern scientific concept of the four states of aggregation, and plasma, obviously, corresponds to fire. The properties of plasma are studied by plasma physics.*



*Ampedokl*

*Kruks*

*Lengmur*

# Plasma forms

## Artificially generated plasma

1. Substance inside fluorescent (including compact) and neon lamps.

2. Arc discharge from Tesla's transformer.

3.Luminous sphere of a nuclear explosion.

## Terrestrial natural plasma

1. Lightning

2. Lights of St. Elmo.

3. Ionosphere

4. Tongues of flame

## Space and astrophysical plasma

1. The sun and other stars

2. Solar wind

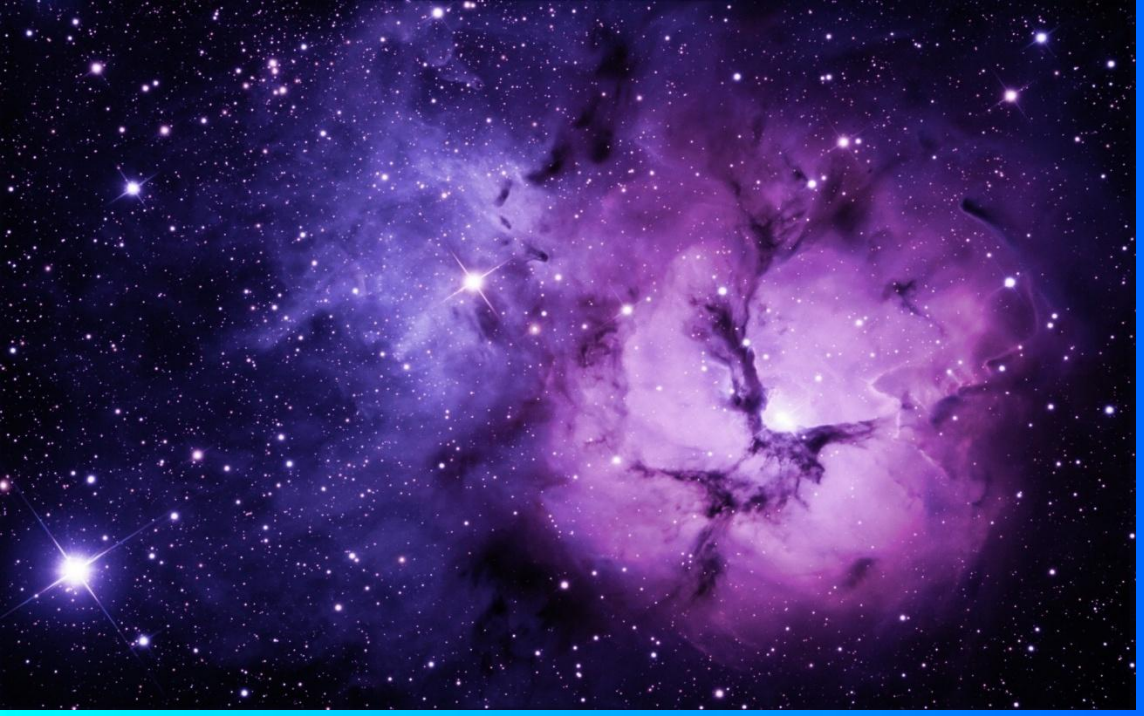
3. Interstellar nebulae

*According to today's concepts, the phase state of most of the matter (by mass about 99.9%) in the Universe is plasma. All stars are composed of plasma, and even the space between them is filled with plasma, albeit very rarefied (see interstellar space). For example, the planet Jupiter has concentrated in itself practically all the substance of the solar system, which is in a "non-plasma" state (liquid, solid and gaseous).*


Plasma lamp

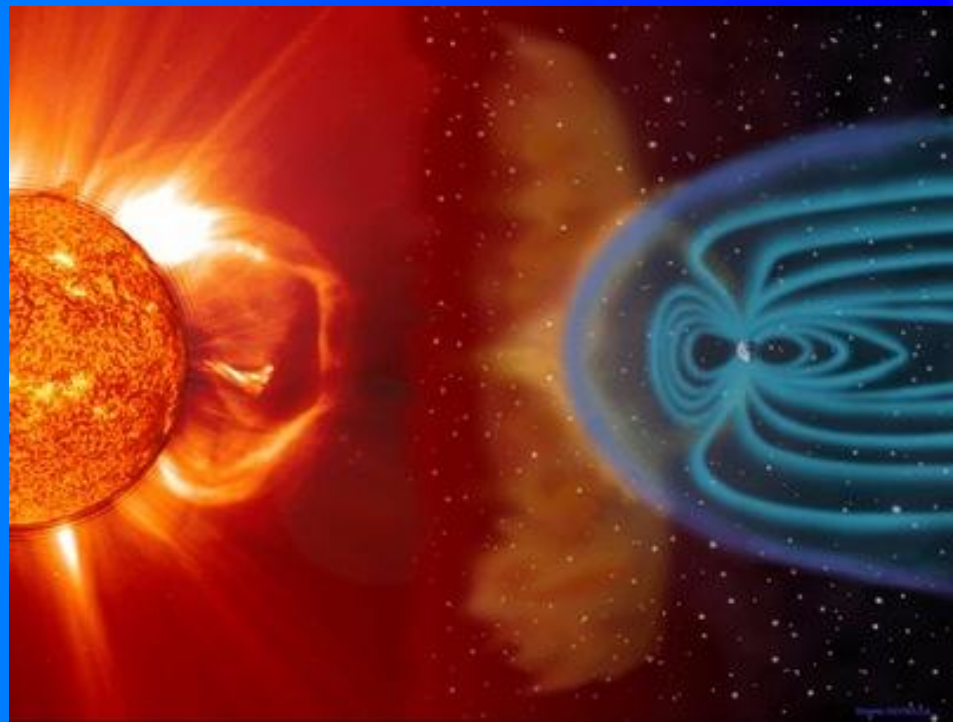

Lightning

northern Lights



*Space*

*sunny wind*



# Plasma properties and parameters

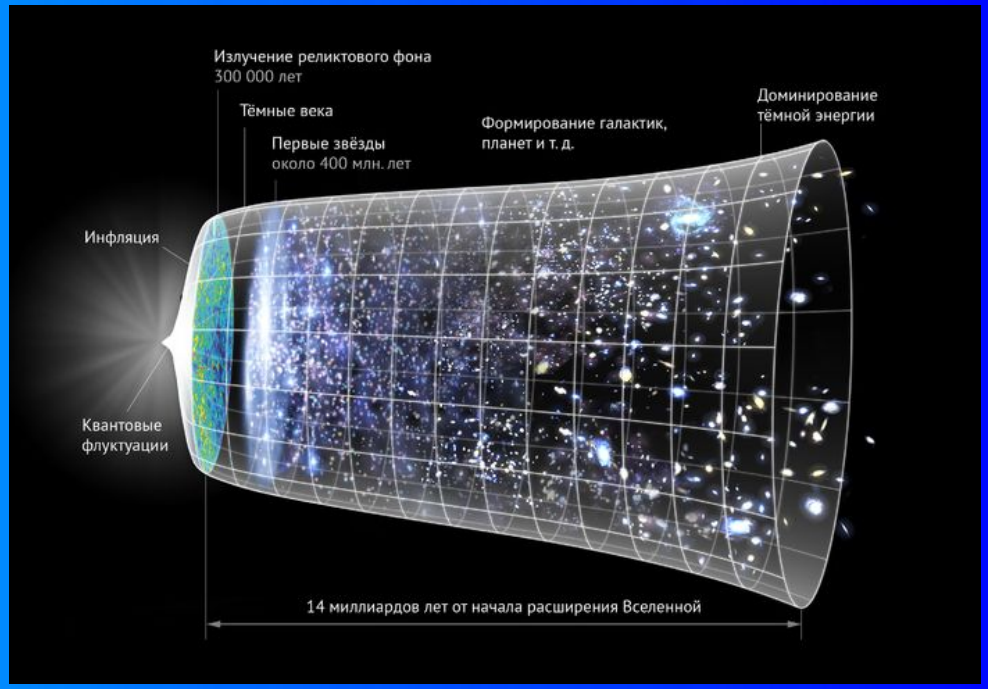
***1. Sufficient density:*** *charged particles must be close enough to each other so that each of them interacts with a whole system of closely spaced charged particles.*

***2. Priority of internal interactions:*** *the Debye screening radius should be small compared to the characteristic size of the plasma. This criterion means that the interactions occurring inside the plasma are more significant in comparison with the effects on its surface, which can be neglected.*

***3.Plasma frequency:*** *the average time between particle collisions should be long compared to the period of plasma oscillations. These oscillations are caused by the action on the charge of an electric field arising from the violation of the quasineutrality of the plasma. This field seeks to restore the disturbed balance.*

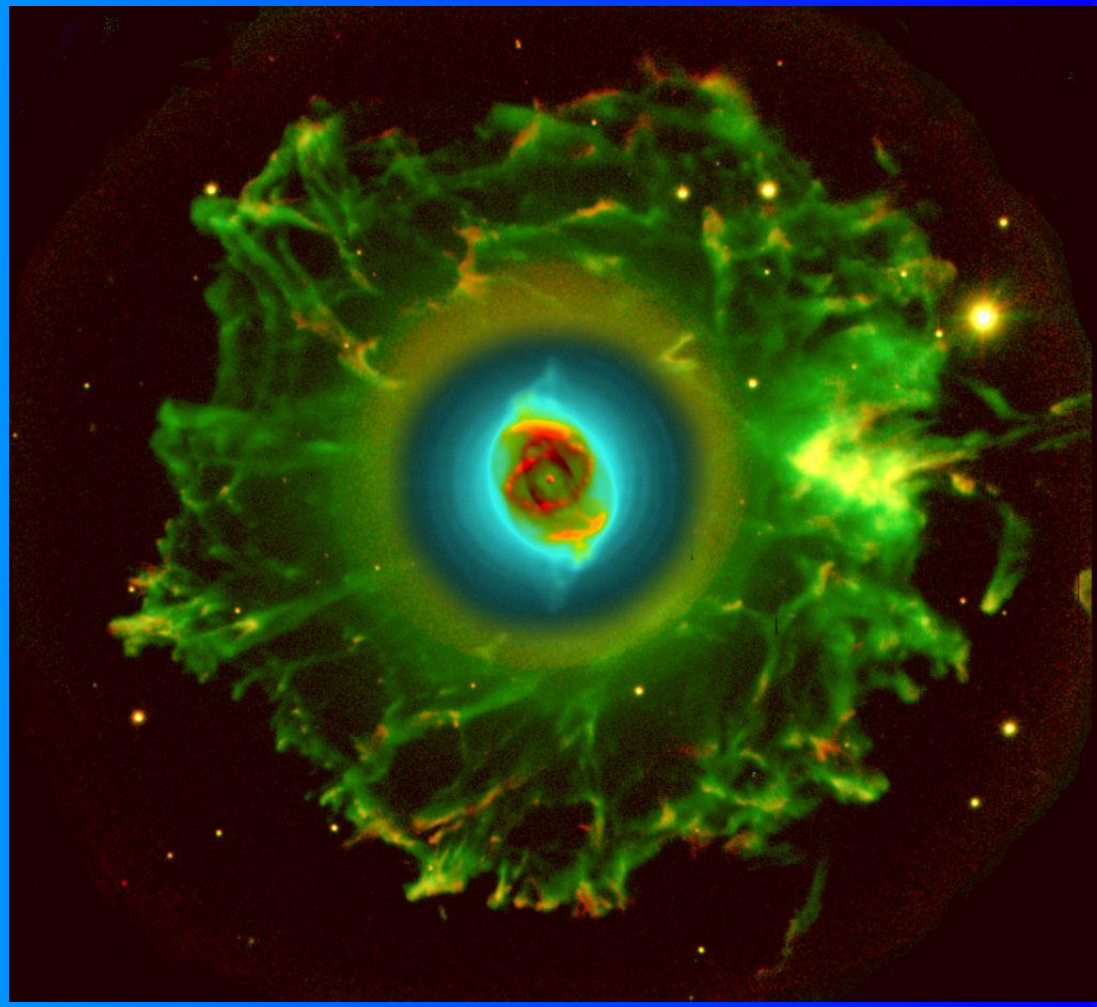
# Temperature

***Plasma is divided into low-temperature (temperature less than one million K) and high-temperature (temperature one million K and above). This division is due to the importance of high-temperature plasma in the problem of implementing controlled thermonuclear fusion. Different substances pass into the plasma state at different temperatures, which is explained by the structure of the outer electron shells of the atoms of the substance: the easier the atom gives up an electron, the lower the temperature of the transition to the plasma state.***



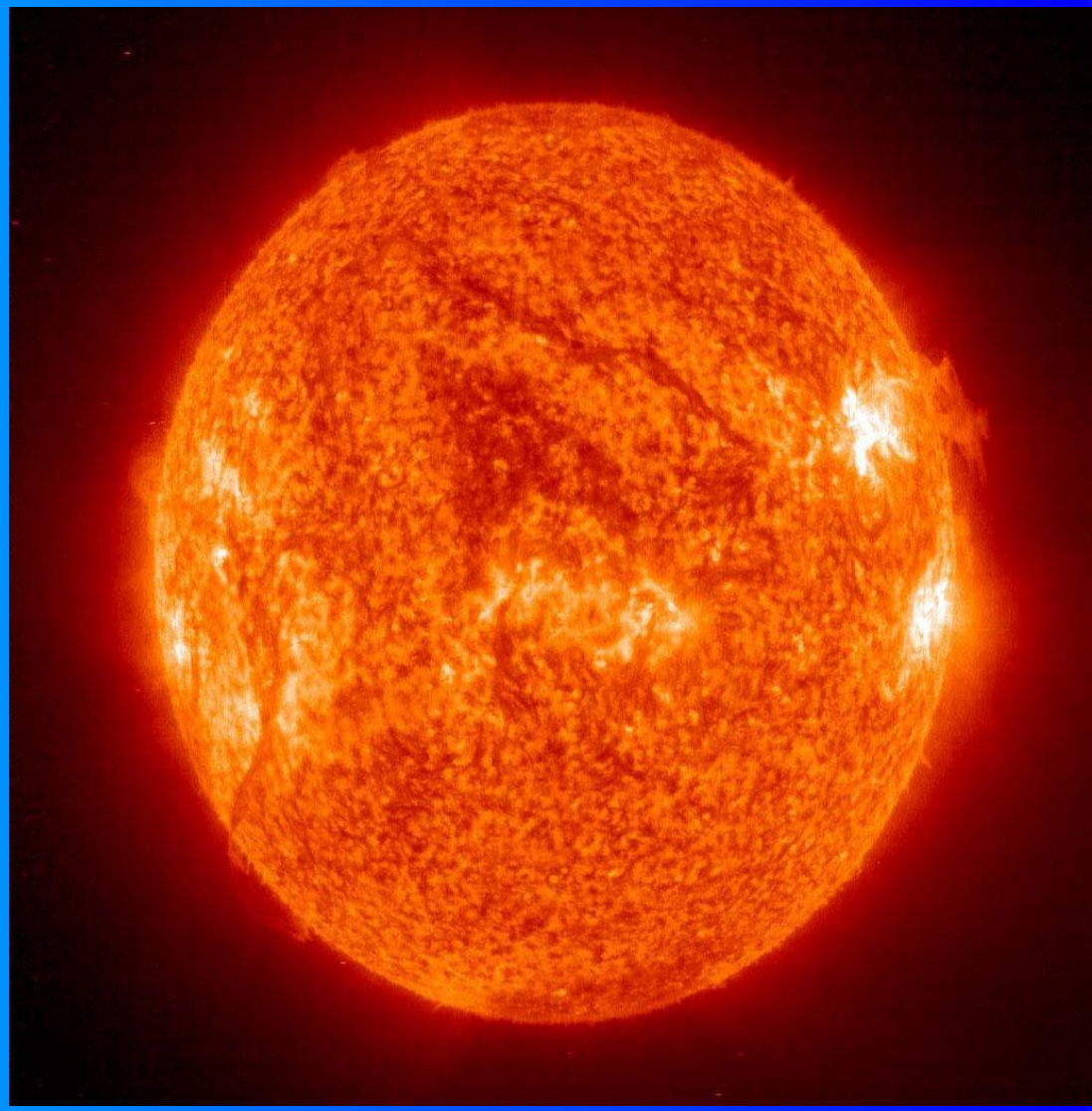

# Degree of ionization

*In order for the gas to pass into the plasma state, it must be ionized. The degree of ionization is proportional to the number of atoms that have donated or absorbed electrons, and most of all depends on the temperature. Even a weakly ionized gas in which less than 1% of the particles are ionized.*



*Low-temperature plasma applications include plasma modification of surface properties (diamond films, metal nitriding, alteration of wettability), plasma etching of surfaces (semiconductor industry), gas and liquid purification (ozonation of water and combustion of soot particles in diesel engines).*

*Hot plasma is almost always fully ionized (degree of ionization ~ 100%). Usually it is she who is understood under the "fourth state of aggregation". The sun is an example.*



# *Density*

*Besides temperature, which is fundamental to the very existence of plasma, the second most important property of plasma is density. The phrase plasma density usually denotes the density of electrons, that is, the number of free electrons per unit volume (strictly speaking, here, density is called concentration - not the mass of a unit of volume, but the number of particles per unit of volume). In quasineutral plasma, the ion density is related to it by means of the average charge number of ions:. The next important quantity is the density of neutral atoms. In hot plasma, it is small, but it can nevertheless be important for the physics of processes in plasma. When considering processes in dense, nonideal plasma, the characteristic density parameter becomes, which is defined as the ratio of the average interparticle distance to the Bohr radius.*

# Plasma in space

*Under terrestrial conditions, due to the relatively low temperature and high density of terrestrial matter, natural plasma is rare. In the lower layers of the Earth's atmosphere, the only exceptions are lightning strikes.*

*In the Universe, the bulk of matter (about 99.9%) is in the state of plasma. The sun and stars are formed from plasma, the ionization of which is caused by high temperatures. So, for example, in the inner region of the Sun, where thermonuclear fusion reactions take place, the temperature is about 16 million degrees.*

*Plasma streams from the surface of the Sun create interplanetary plasma. The electrons of this plasma are captured by the Earth's magnetic field and form radiation belts around it (at a distance of several thousand kilometers from the Earth's surface).*

*Fast electrons and protons, entering the Earth's atmosphere, cause the appearance of auroras in northern latitudes.*