Dr. L. Körtvélyessy

THE FIFTH STATE OF MATTER

Published:
Coronae 2001 NL Nordvijk

Content:
KEY WORDS: ........................................................................................................................................... 2
SUMMARY .................................................................................................................................................. 2
INTRODUCTION ......................................................................................................................................... 2
DOES THE HOTTEST STAR CONSIST OF PARTICLES OF THE HIGHEST ENERGY ? ....... 3
PHYSICS OF THE FILAMENTS : THE FIFTH STATE OF MATTER....................................................... 3
THE SOLAR CORONA IS NOT HOT BUT POSITIVELY CHARGED !.................................................... 4
THE SOLAR CORONA IS IN THE FIFTH STATE OF MATTER............................................................... 4
RECENT ASTRONOMY FINDS MANY FILAMENTS ............................................................................. 5
THE PARTICLES OF THE HIGHEST ENERGY: THE COSMIC RAYS ................................................. 6
REFERENCES ........................................................................................................................................... 8
KEY WORDS:

Acceleration of particles, corona, corona problem, cosmic rays, filament, flux tube, heat-motion, high energy astrophysics, hypernova, jet, lightning, magnetic tube, non-thermal-phenomena, solar dynamo, state of matter, supernova, temperature-scale.

SUMMARY

The astonishing development of astronomy often shows beautiful filament-systems. All these filaments have an exact circular cross section, they mostly transport matter against gravity. They are normally seen to be of plasma, but the physics of these filaments suggests a non-thermal, a fifth state of matter in which particles have $10^{21}$ times higher energy than those in the hottest stellar plasma.

INTRODUCTION

Ice is transformed to water at $0^\circ$C when the energy of its molecules (particles) increases. Water is similarly transformed to vapour at $100^\circ$C (Fig.1). Much stronger zig-zag motion of the particles separates and ionises hydrogen and oxygen i.e. plasma comes into existence (above 13 000 K). Do all bodies fit one of these four states of matter even when strongly heated?

This year, the solar corona-problem is 60 years old. The solar corona - which floats visibly during the solar eclipse as a pale green fire - does not fall onto the solar surface. Thousands of other solar filaments seem not to obey gravity, too. Also, since decades, nobody can understand that millions of sunmasses can be ejected with almost light-velocity via jets in the extremely strong gravity of a black hole. Another problem is that the temperature of the solar filaments seems to be much higher than that of the Sun i.e. the corona and other filaments do not seem to obey the thermodynamic law that heat does not flow uphill (Lang). And, why can we not see the “very hot” solar corona and flares through a grey filter?

This paper calls to mind that all these celestial bodies which do not seem to obey gravity and thermodynamics - have a filament form. Filaments were mysterious for decades. Now, this paper shows them not in the fourth but in the fifth state of matter. No new and new models like magnetic tubes, magnetic beds, magnetic tornados, shock waves, interactions of two stellar winds are necessary only a new state of matter for all filaments and jets up to a length of ten lightyears. Where is the fifth state of matter in the temperature scale (Fig.1)? Can we find it somewhere above the plasma-range? Calculations explain why it has not been discovered earlier. The corona and other filaments are well known since decades. These non-thermal bodies are the largest and heaviest in the Universe, but they have kept their mystery till now. For example, they have no temperature.

![Fig. 1 The cold end of the temperature scale (The low range of the particle-energies)](image)
DOES THE HOTTEST STAR CONSIST OF PARTICLES OF THE HIGHEST ENERGY?

Celsius’s scale (1742) did not show a coldest or hottest end (Fig.1). However, Kelvin’s scale (1851) had a natural coldest end at 0 K where the zig-zag motion of the particles nearly stops. Matter of a temperature of -1 K cannot exist (Fig.1) but the Kelvin-scale does not have its hottest end so far. However, we can find its natural hottest end by taking the Stefan-Boltzmann law into account. The power of the heat-emission at T temperature of all stars is:

$$P = \Phi T^4$$

(1)

where $\Phi$ is the heat-radiation constant ($6.7 \cdot 10^{-8} \text{ m}^2 \text{ K}^{-4}$). From its approx. $10^9 \text{K}$ hot plasma, a supernova emits as much heat as a galaxy, according to equ.1. A hypothetical “hypernova” of $10^{10} \text{K}$ would radiate obviously not 10 times more power than the supernova, but $10^5 = 10,000$ times more! This lost heat should have been produced by the forming of 10,000 neutron stars and not by only one neutron star. This “hypernova” would radiate as 10,000 galaxies, which was neither observed nor shown by a model. And what would a “hypernova” of $10^{11} \text{K}$ or even of $10^{12} \text{K}$ do? **The stars have a natural upper limit in order of $10^9 \text{K}$**. However, the particles of a supernova of $10^9 \text{K}$ do not have the highest energy in the Universe. Their average energy $E$ is shown (2) if their velocity is $v$ and mass is $m$ at temperature $T$:

$$E = \frac{1}{2}mv^2 = \frac{3}{2}kT$$

(2)

where $k$ is the Boltzmann constant: $1.38 \cdot 10^{-23} \text{ J/K}$. (Electrons in the TV-beam have a particle-energy $E$ of 26 000 electronvolt due to their accelerator-voltage of 26 000 V. The solar surface has about 1 eV, the solar core 2 000 eV or 15 million K.) The supernova-particles of $10^9 \text{K}$ have $10^5$ eV.

The temperature of the stars seemed unlimited because the energy of a particle in the cosmic rays has no upper limit at $10^5 \text{eV}$ - at the natural limit of plasma. The measured upper limit is at $10^{21} \text{eV}$! One such particle could elevate 16 kg into the altitude of 1 m but a particle of the hottest star only $10^{19} \text{mm}$. Where do these cosmic ray particles originate? Surely not in the stars! It is easy to calculate via equ. 1 that a “super-hypernova” should have the fusion-power of $10^{84}$ suns in order to have these particles of $10^{21} \text{eV}$ on its „plasma-surface“! Therefore, the high energy of the cosmic ray particles should not suggest an unlimited temperature scale in the plasma. Rather, it shows an undiscovered process of acceleration in an unknown celestial body. „Lots of unsolved problems...are connected with particle acceleration“ (Trimble). The cosmic ray particles are the witnesses of celestial bodies of particle energies of $10^5 - 10^{21} \text{eV}$. These bodies cannot be the stars (of maximally $10^5 \text{eV}$). These celestial bodies are the filaments (Fig. 2-9) as shown below.

PHYSICS OF THE FILAMENTS : THE FIFTH STATE OF MATTER

Calculating the heat emission, we can test whether e.g. the TV-beam (or a proton beam) obeys equ.1? The electron current $I$ is 0.001 A, the voltage $U$ is 26 000 V, therefore the power $P$ is

$$P = U \cdot I = 26 000 \text{ V} \cdot 0.001 \text{ A} = 26 \text{ W}$$

(3)

Electrons in the TV-beam have 26 000 eV i.e. 13 times higher energy than electrons (or protons) of the solar core-plasma (2 000 eV=15 million K). Usually, all bodies of very energetic particles were considered to be of plasma. Does this TV-beam consist of a very energetic plasma? If yes, this plasma would emit the received electric power of 26 W as a heat-power of 26 W (equ.1)!

The calculation in detail is as follows: The beam has a diameter of 0.1 mm and a length of about 500 mm, its surface is 150 mm². The solar surface emits 63 W/mm², therefore, the TV-beam would emit 63 W/mm² - 150 mm² = 9450 W if its „temperature“ would be equal to that of the solar surface. But we must take the „temperature“ of the beam of 13 $\cdot$ 15 million K = 195 million K into account (equ.2) ! The relation of the „temperature“ of the beam and the temperature of the solar surface is:

$$195 000 000 \text{K} / 6000 \text{K} > 180 000 000 \text{K} / 6 000 \text{K} = 30 000$$

We must take the product of 9450 W and 30 000 ⁴ according to the $T^4$ law (equ.1). This power is:
10^{22} \text{ W} \text{ and not 26 W}! \text{ About 40 000 TV-beams of a small city would radiate more power than the whole Sun if the TV-beam was of plasma! This impossible result proves that the TV-beam (or an ion-beam) is no plasma body! It does not obey the heat radiation law (equ.1). This result can be simply understood because the beam-electrons fly parallel to the beam-axis. The zig-zag-motion of a plasma does not exist in it. Such particles do not emit heat, independently of their high (or low) particle-energy. The TV uses all its 26 W for the acceleration of its electrons and emits zero Watt heat. Heat is emitted only by bodies of heat-motion. But the zig-zag motion in the electrongsas around the hot cathode (of some 10^{-2} \text{ eV i.e.1000 K}) is smoothened by the voltage of +26 000 V to a parallel flight in the TV-tube. This elevation of the particle energy by 6 orders transfers the electrons from a thermal (gas)-state of matter into the non-thermal state of matter. (Non-thermal phenomena: Conti and Underhill.)

Fig. 2  Terrestrial filaments (Stormguy)  
Fig. 3 Celestial (solar) filaments (TRACE)

The TV-beams, the ion-beams, sparks from electrified combs and clothes, X-ray tubes, lightnings (Fig.2) in our everyday life do not emit heat. In vacuum, the lightning would be invisible and smooth as the TV-beam. With its 100 million Volt, it would emit heat as much as 10^{17} \text{ suns} from its body of e.g. 3000 m^3 with its very high particle energy of 10^8 \text{ eV} (equ.1)! Solid, liquid, gaseous and plasma bodies do have the heat-motion, but these filaments do not. Above these four „thermal states of matter” we can recognise a fifth, a „non-thermal state of matter”. A filament is a parallel flight of either electrons (Fig.2) or ions (Fig.3). This motion of the particles is the simplest among all states of matter. This parallel flight binds the beam-electrons strongly together via pinch effect i.e. the electrons in flight are negative currents. Parallel currents attract each other and look for the minimal cross section which is the circular cross section. This can be observed on the TV-screen and in all filaments of a diameter of 0.01 mm (in CERN) up to many 1000 lightyear (in radiogalaxies). Coronal filaments have the same width on the solar disc and on the limbs i.e. these ion-filaments also have an exact circular cross section. The electrically neutral jet of an aeroplane has no filament-state, therefore, it cannot keep its circular cross section. Non-electric astronomy erroneously thinks that all filaments are neutral. Therefore it needs millions of mysterious magnetic tubes in many lengths.

THE SOLAR CORONA IS NOT HOT BUT POSITIVELY CHARGED! 
THE SOLAR CORONA IS IN THE FIFTH STATE OF MATTER

Why do thousands of the solar filaments (Fig.3) have a circular cross section (Klimchuk 1992, 1999)? Hale, Bruce, Körtvélyessy, Crew described electric models of the Sun which is a huge thermo-element. It thermally separates electrons and ions via equ.2. The 1836 times lighter electrons have, in all temperatures, the same energy as the protons but a \sqrt{1836} = 43 times higher velocity. This charges the solar surface negatively and the core positively. The solar wind is the electrostatic explosion of these thermoelement-electrons, the solar filaments are the electrostatic explosion of the surfaced positive charge. After a four years rise of the positive charge, a solar iron-ion-filament is electrostatically ejected from an UV-bright (positive) surface-area and lands in an UV-dark (negative) area, named unfortunately „coronal hole”. In Fig.3, ion-filaments are ejected by the red area on the right and land on the dark area on the left. Immediately after the ejection, the jet will be narrow via pinch effect. (“Hot plasma” would expand as a cloud in all directions !) For solar filaments, no „dynamo-made
magnetic tubes of a circular cross section” are necessary because the parallel flying e.g. iron ions produce their own circular magnetic field via pinch effect. The coronal filaments are not tubes somehow filled with million K hot plasma; in this case the foot-point of only one coronal filament would emit more heat than 800 000 suns (equ.1). Moreover, these “magnetic tubes” would be strongly deformed via their transport from the dynamo to the surface through the boiling layers (Schrijver and Title). TRACE clearly shows the parallel flight of iron ions, from surface to surface (Fig.3). The ionisation does not change along the flight, therefore, no “heating” or “cooling” occurs. This flight obeys gravity, but due to the electric ejection, this falling cannot be measured. The ejection of a filament is always possible in the case of the Sun or even at the black hole because the electrostatic repulsion is $10^{36}$ times stronger than gravity between two protons. The electrically emitted coronal ions fly along straight lines, they cannot emit any electromagnetic waves from their very high motion energy, no X-ray, no UV. But they emit X-ray and UV (Fig.3) from their electric energy via recombination of ions. This clear difference between thermal- and non-thermal bodies eliminates all corona-problems. The corona obeys gravity, thermodynamics. It has a filament-form like all electrically ejected matter.

A filament can even oscillate as a bell! A larger diameter increases the pinch-effect, the smaller diameter increases the mutual electrostatic repulsion among the ions in a diameter-oscillation (see 10.7 cm-oscillation). Both forces act with light velocity. This broadens the spectral lines.

The landing filament often over-charges the negative solar gas layer and a new filament starts from this local positive spot, see weak radial filaments on the left in Fig.3. Also the „post flare loops” show transformations between these two states of matter upwards and downwards.

**Fig. 4 Filaments of penumbrae (W. Lille)**

**Fig. 5 Filaments of a planetary (STScI)**

**RECENT ASTRONOMY FINDS MANY FILAMENTS**

Galileo saw the penumbra of the sunspots. Larger telescopes show no grey ring but 100-200 fine dark filaments around the sunspots (Fig.4). Herschel named small, structureless and round spots „planetary nebule”, the Hubble Space Telescope resolves about 40 fine filaments in the Eskimo planetary-nebula (Fig. 5). Skylab detected puzzling layers of the solar corona. SOHO and TRACE show no layers but hundreds of very fine filaments which culminate mostly higher if their atoms are stronger ionised (Fig. 3).

**Characteristics of bodies in the fifth state of matter:**

1. They all have a filament-form, their particles fly parallel to the filament axis.
2. They mostly have particles of higher energy than those of the plasma bodies.
3. In spite of the very high particle-energy, they all do not emit heat (lacking heat-motion).
4. They all have a circular cross section and, therefore, a more or less bent cylindrical body.
5. Like crystals, they have a characteristic form, also in their smallest branches (Fig.2).
6. They can oscillate with supersonic frequencies (solar radiation on 10.7 cm?).
7. They move as though gravity would not exist even in the very mouth of a black hole.
8. Their electric charge is either positive or negative. Their overbalance is never neutral.
ROSAT showed the supernova remnant Cassiopeia A as a hot, round, X-ray emitting plasma body (Fig.6), however, Chandra reveals its about 200 fine filaments (Fig.7) which explain the missing thermal radiation and almost gravity-free expansion via the fifth state of matter (Fig.10). Its positive charge explains that the Crab-nebula expands by 8% accelerated (Nugent)! The jets of the Vela- (Fig.8) and Crab- (Fig.9) pulsars were shown as coaxial to the rotational axis. Very strong gravity of the pulsar cannot retard these electrically ejected particles, moreover, the pulsars seem to be pushed by the stronger jet with a velocity of 100 km/s and 150 km/s respectively. Radiotelescopes show (up to 15 million lightyears long) one or two jets of radiogalaxies and the ejected millions of sunmasses.

![Fig. 5 Cassiopeia A (ROSAT-bubbles)](image1)
![Fig. 6 Cassiopeia A (Chandra-filaments)](image2)

THE PARTICLES OF THE HIGHEST ENERGY: THE COSMIC RAYS

Cosmic ray particles have a so far clear limit at $10^{21}$ eV. Why? Similar to the upper limit of the temperature scale at about $10^9$ K, we can find an upper limit of the particle energies at $10^{26}$ eV, by 21 orders higher than the thermal limit of $10^5$ eV. This can be explained as follows:

The supernova-implosion produces a positively charged neutron star which partly inherits the positive charge excess of the presupernova-core. The outermost surface layer of a neutron star is covered by one layer of protons. (A second layer cannot be fixed, it is repulsed by the first one.) The electric charge of this „mono-proton layer” is easy to calculate. On a sphere of an $R$ radius of 8 km, protons are fixed via strong nuclear force. (Their volume is less than 1 cm$^3$!). One proton needs an area of $\left(10^{-15}\right)^2$ m². The highest $Q$ electric charge is given by the relation of these areas:

$$Q = +1.6 \cdot 10^{-19} \text{Coulomb} \cdot \frac{4\cdot\pi \cdot 8000^2 \text{m}^2}{10^{-30} \text{m}^2} = +10^{20} \text{Coulomb}$$

The voltage $U$ of this sphere is:

$$U = 9 \cdot 10^9 \cdot \frac{Q}{R} = \frac{10^{10} \cdot 10^{20}}{8000} = +10^{28} \text{Volt} \quad (4)$$

Probably, this is the highest voltage of the Universe (Körtvélyessy 1999). It is easy to calculate that this very concentrated positive charge in quick rotation produces the strongest magnetic field of the Universe in the order of $10^{10}$ Tesla. This electric model of the neutron star claims that the magnetic axis is identical to the rotational axis exactly as Fig. 8-9 show. If an atom or a meteor falls in the direction of the neutron star, it will be attracted by the very strong gravity of the star. But in a distance of e.g. 800 m, this falling neutral matter will be torn to electrons and ions by the huge electrostatic field. The electrons are attracted onto the positive surface (and remain there) and the ions are repulsed in the jets (Fig.8-9) along lightyears, accelerating to the highest non-light-velocities in the Universe. These ions are the cosmic ray particles! This model explains that the heavy ions and not the light electrons are the cosmic ray particles (contradicting the thermal law of equ.2 and the shock-model of the explosion). Less than 0.1% electrons are in the cosmic rays, inconsistently with all thermal-, mechanical- and magnetic- but consistently with this electric-model of acceleration.
The active (positive) Sun repulses these positive ions; their flux is lower during solar maximum and after every flare (Forbush effect). Since the last months, NASA speaks about a “proton storm” (and no “electron storm”) during a mass ejection of the Sun. These protons repulse the positive cosmic ray particles too, and therefore, lower the terrestrial flux of the cosmic rays.

The acceleration-force of these ions continually pushes back the star, too. Perhaps a calculation will show a big relativistic mass of these ions and explain the velocities of the pulsars (see arrows of 100 km/s and 150 km/s in Fig. 8-9). (The electric repulsion-force does not stop after the ejection!)

This electric model explains also the measured upper limit of the cosmic rays at $10^{21}$ eV. (Perhaps $10^{22}$ eV will be found, too.). The theoretic limit is $10^{26}$ eV (equ.4). The „electric neutron star” above can only contain a higher positive charge if it has a larger diameter due to its mono-proton layer (equ.4). But the neutron star cannot have a larger diameter without limit because it collapses into a black hole already at three sunmasses. Therefore, a cosmic ray particle of an energy of e.g. $10^{30}$ eV cannot exist (Fig.10). The fifth state of matter is the most energetic one because a sixth state of matter between e.g. $10^{26}$ eV and $10^{35}$ eV is not possible.

**Fig. 9** The high ranges of the particle energies in the 3rd, 4th and 5th states of matter. Thermal bodies exist up to $10^3$ eV, non-thermal bodies up to $10^{21}$ eV, theoretically up to $10^{26}$ eV. Cosmic rays are continually (not only once!) accelerated in the jets of the neutron stars (Fig.7 and 8).
REFERENCES

Hale, G E. National Academy talk (1913) cited by Lang p 79
Bruce, C E R (1941) Nature 47 p 805-806
Kimchuk, J A et.al (1992) PASJ 44 L 181
Kimchuk, J A (1999 Marc 25) private communication
Lang, K R (1995) Sun... Springer 282 p
Nugent, R L (1998) PASP 110 p 831-836
Trimble, Virginia (1999 Dec 9) private communication