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Review paper

CO-EXISTENCE OF TWO PLASMA PHASES IN SOLAR AND AGN CORONAS

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SUMMARY: Here we have juxtaposed two distant cosmic locations of the Sun and AGN where neutral hydrogen appears in a close connection with hot coronas. Besides the solar photosphere, chromosphere and prominences where the presence of neutral hydrogen is well established, its emission quite high in hot solar corona is still puzzling. Some of earlier observations where H_α emission in solar corona was detected in eclipse and in daily coronagraphic observations are reviewed. A proper theoretical explanation of this cold chromospheric-type emission in the hot corona does not exist yet. On the other side, a similar emission of hydrogen lines is present in Active Galactic Nuclei (AGNs). Much research work is currently being done in this field. We outline some of the concepts of the AGN structure prevailing in the astrophysics today.

1. INTRODUCTION

In solar photospheric and chromospheric spectra, originating at temperatures from 4000 K to $5{\cdot}10^4$ K, the hydrogen absorption or emission spectral lines are always present. Apart from them, the Balmer emissions - intrinsic or somehow reflected - were noticed in the coronal spectrum more than a century ago. The majority of solar physicists are now convinced in the intrinsic coronal origin of those low excitation emission regions. However, in most cases their sizes, locations in the corona, appearance, time-variations and possible theoretical explanations are not well established yet. The presence of the neutral hydrogen emission implies the co-existence of a cool plasma phase of the temperature about 10^4 K with the hotter one of 10^6 K.

Not insisting on an exhaustive list of localities where hydrogen appears in the Universe, one may find interesting to notice a certain degree of similarity of the radiation processes of hydrogen in solar corona and in AGNs. Here we review the solar as well as the AGN cases of Balmer emission originating in the hot low-density plasma surroundings. The basic concept of such an approach was presented at the 19th SPIG (Arsenijević *et al.* 1998).

2. THE SOLAR CASE

2.1 The Base of Solar Corona

For the sake of a detailed research the hot plasma sphere called the Sun is in radial direction usually divided into several layers: the core, interior, convective zone, photosphere, chromosphere and corona. The last three are sometimes called the solar atmosphere or solar outer layers. The photosphere and chromosphere represent the lower boundary of the corona. Its upper limit is not sharp: the corona gradually rarefies into the interplanetary space.

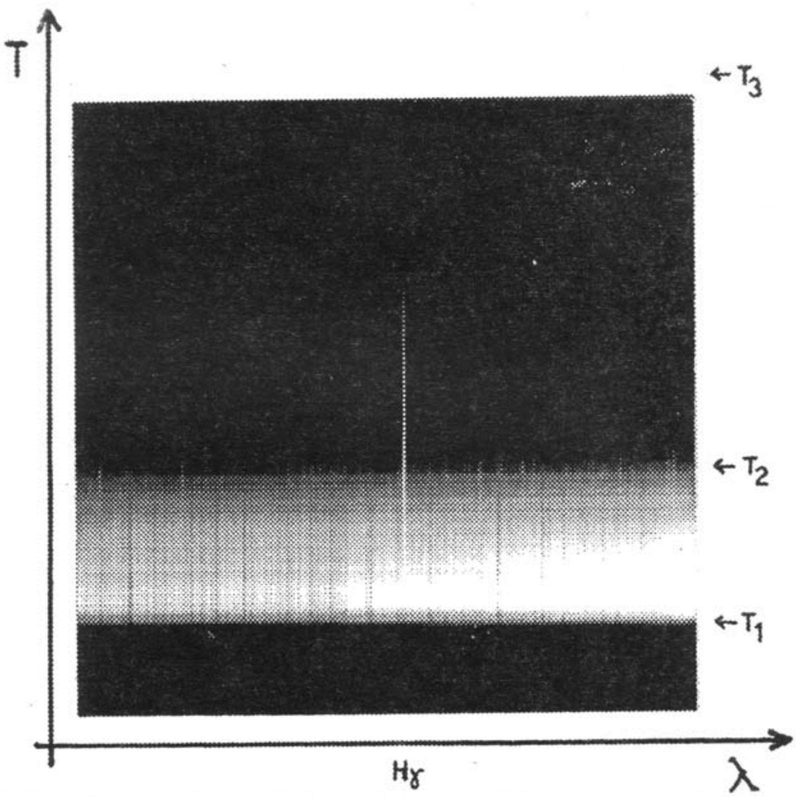


Fig. 1. *The eclipse February l5, 1961 flash spectrum taken with a kind of moving plate. The wavelength (4215 Å to 4472 Å) increases towards right, the time increases upwards:* T_1 = *start of the exposure,* T_2 = *the complete fading of the continuum (the eclipse totality begins), and* T_3 = *the end of the exposure. Notice the conversion of* H_γ *(the brightest emission line near the center) and many other spectral lines from absorption in the photosphere into emission in the chromosphere.*

The photosphere, a layer about 300 km thick, with its upwards decreasing temperature from about 6000 K to 4400 K and electronic density of 10^{12} cm^{-3} at its upper boundary, irradiates strong optical and IR continuum and absorption spectrum containing numerous absorption spectral lines of neutral and low-ionized atoms. Immediatelly above it is the chromosphere, the layer transparent in the continuum wavelengths but with many emission spectral lines excited at temperatures higher than 4400 K up to about $5 \cdot 10^4$ K and electronic densities from 10^{12} cm^{-3} to 10^{10} cm^{-3} (Allen 1964).

To the heights of about 3000 km from the photosphere, the chromosphere is a turbulent but more or less compact medium. After that, it disintegrates into a great number of narrow streams called spicules. Looking at the chromosphere near the solar limb, one easily resolves spicules at heights of about 5000 km. The highest spicules can extend up to $1.5{\cdot}10^4$ km or somewhat more. The space between spicules above the height of 3000 km is filled with the coronal plasma (Athay 1965). The low levels of corona contain magnetic fields of various scales originating in the photosphere or below it. The fields have a very complex and variable structure. Driven by various photospheric motion, mainly of granular and supergranular size, a kind of "braiding" and subsequent frequent reconnections of magnetic field lines occur. The energy released in this process effectively heats the corona (Schrijver *et al.* 1998). A wide range of coronal heights is involved: from the lowest levels hidden somewhere behind the chromospheric spicules to the heights of large diffuse coronal loops comparable with the solar radius (Priest *et al.* 1998). This heating process is permanent - at smallest scale it does not depend on solar activity - and it is more than sufficient to keep the corona at temparatures of the order of 10^6 K.

The two mentioned spectra, the photospheric absorption and chromospheric emission one are nicely seen and can be recorded as they convert one into the other on rare occasions of total solar eclipses. Namely, the Moon near the totality of an eclipse slowly scannes the both layers, covering or uncovering the solar limb (Fig. 1). Here, the so called "flash-spectrum" is recorded by a modified "moving plate" technic (Kubičela 1968). During a 45-second long exposure that started at T_1 and lasted untill T_3, the part of the photosphere giving the spectrum at the bottom of the record in Fig. 1 was slowly covered by the Moon untill the last trace of continuum spectrum disappeared at T_2 and only the chromospheric emission lines remained to be recorded. The Balmer lines are present in both spectra. The brightest and the highest emission line at the center is H_γ. The covered spectral interval runs from 4215 Å to 4472 Å.

Taking into account the temperatures and densities in these two layers as well as in the corona (having temperature of the order of 10^6 K and an electron density decreasing upward from $4 \cdot 10^{10}$ cm^{-3} at its base to $2 \cdot 10^6$cm^{-3} at the height of about $3 \cdot 10^6$ km) one would not expect the Balmer emission higher than in chromosphere, exclusive of prominences. Actually, the intrinsic emission spectrum of corona ("E-corona") contains spectral lines of highly ionized elements. For example, the most known visual spectral lines are the green FeXIV 5303 Å and the red FeX 6374 Å. Also, hot active features in the corona strongly emit at many X-ray, UV and radio wavelengths.

2.2 Some Previous Solar Observations

The first observations of low excitation spectral lines in solar corona were recorded in the last century. Namely, during the 1868 eclipse, Rayet noticed H_β, D, as well as 5303 Å spectral lines high above the prominences. Also, Janssen on the occassion of the 1871 eclipse spectroscopically (radial spectroscope slit) found hydrogen emission lines 10' above the Moon's limb (Dermendjiev 1997).

Later on, mainly in the first half of this century, some observers did not believe in solar origin of the recorded low excitation emission in corona. It was suspected to be the chromospheric radiation scattered in the Earth's atmosphere or, in some cases, it was found to originate in the telescope (Zirin *et al.* 1964). Here we review some more or less successful observations where the recorded "cold" emission was supposed to originate in the solar corona.

In the 1952 eclipse H and K CaII and H_γ lines were registered at a distance 70' from the Moon's limb and explained as local appearance of a diffuse prominence matter (Colacevich 1952).

During the 1970 eclipse, Gurtovenko and Alikayeva (1971) observed low excitation emission $4 \cdot 10^4$ km to 10^5 km high in the corona. At the same position a system of thin, dense streamers was found. Elaborating the same observation, Alikayeva (1975) found H, He and some neutral metal emissions and estimated the intensity of this "cold" emission as being about 1000 times weaker than in prominence spectra. She also estimated a possible temperature value between 10^4K and $3 \cdot 10^4$K, as well as the electron density between 10^9 cm^{-3} and 10^{10} cm^{-3}.

Bappu *et al.* (1972) observed coronal spectrum during the 1970 Mexican eclipse. As the most striking low excitation spectral lines they found HeI 5876 Å and H_α followed by the less intense lines H and K CaII, H_γ, H_ζ, H_η and D3 with the maximum intensity at about 0.5 solar radii above the Moon's limb. The typical coronal lines FeXIV 5303 Å and FeX 6374 Å appeared closer to the Moon's limb. The authors readily explained the phenomenon as "a cool column in the outher corona".

Some years ago, a program for daily monitoring coronal H_α structures started at Pic du Midi (Niot and Noens 1997). They use the Lyot coronagraph and a three-cavity interference filter centered at H_α with a 3.3 Å passband. This program is concentrated on rapid and energetic H_α structures very close to the solar limb - which is needed for coopearation with SOHO. As some exemplary results the authors presented rapid time-variations of H_α emission flux lasting from some minutes to one or two hours and amounting to from less than one to more than ten "sunbrightness in 1 arcsec square surface".

Most recently, Foing (1998) during the 1998 eclipse searched for the cold H_α emission in corona. No results have been published yet. However, he suggests us to try such observations in August 1999.

2.3 Modelling the Regions of Solar Cold Coronal Emissions

There are no general conclusive theoretical results on the possible origin of low-excitation (chromospheric) spectral lines in higher levels of the corona. Most often it is assumed that the phenomenon is a transient one - a special short phase in the very complex plasma activity in corona.

One of potential physical mechanisms that might cool coronal plasma is given by Dermendjiev (1997) who in some detail describes the idea (earlier proposed by Öhman) that certain changes of local magnetic field in corona can sometimes decelerate electrons and protons spiralling around the magnetic field lines.The result is local decreasing of kinetic temperature and recombination of hydrogen atoms.

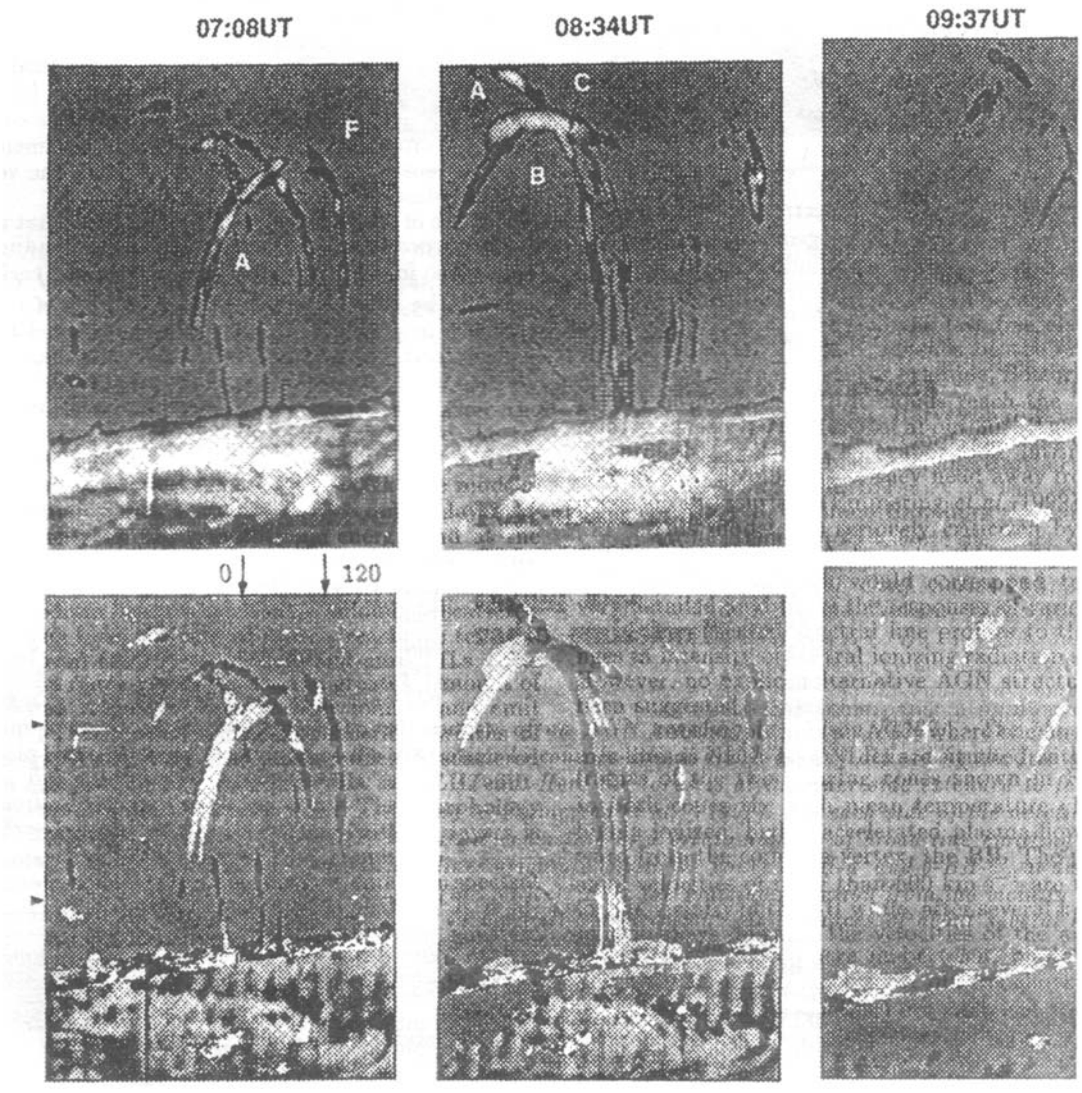
A somewhat more detailed picture of small-scale H_α emission regions in sporadic coronal condensations was presented in Orrall's discussion (Lüst ıet al. 1965). This is an empirical model of a sporadic loop-like coronal condensation. Generally, the high temperature (10^6K) loops are about $1.5 \cdot 10^4$ km thick and radiate in Fe XIV 5303 Å. Embeded in some of these are bundles of fine H_α loops with thickness of 2000 km and temperature less than 10^5K. In a thin transition region between these two components the red FeX 6374 Å emission is radiated. The region that emits the yellow CaXV 5694 Å line is much more extensive. Orrall suggests that in such places the hot coronal plasma cools, compresses and produces small-scale H_α emitting regions. Life-time of that kind of coronal condensations is usually several hours.

2.4 A New Observation

There are several kinds of "coronal loops" - arc structures in corona seen in emission at various wavelengths. The shapes of the arcs or loops are defined by magnetic field lines to which some amount of coronal plasma is "frozen in".

Fig. 2. (left) *Post-flare loops of June 26, 1992 observed with YOHKOH in X-rays with superimposed contours in H_α light at 07:08 UT. Hot plasma at the tops of the loops and at their bases is seen as bright triangle and a flare ribbon respectively.*

Fig. 3. (bottom) *Cool post-flare loops in $H_\alpha \pm 0.3$ Å observed at Pic du Midi: (a) intensity fluctuations (bright is white), (b) Doppler shifts (white/black corresponds to blueshift/redshift). When the intensity is too low, the intensity fluctuations and the velocity in H_α wings at 0.3 Å cannot be computed. These points appear gray as the sky does. The highest arcs are about $9.5 \cdot 10^4$ km high. North is towards the left.*



A multiwavelength observation of such an event that occured on June 26, 1992, after a chromospheric flare, was effected during about 11 hours in soft X-rays by satelite YOHKOH, Fig. 2, and in H_α light at the Observatory Pic du Midi,(MSDP-spectrograph), Fig. 3 (Schmieder *et al.*1995). The mentioned scenario from Orrall's discussion (Lüst *et al.* 1965) has been to a great extent confirmed. The three loop-like, slowly (1.4 kms^{-1}) ascending, arcs seen in H_α light (Fig. 3, upper row) reaching the height of almost 10^5 km, were gradually decaying during the observation. The birthplaces of the cool plasma entities are at the top of the loops where, couple of hours earlier, strong X-ray radiation indicated high temperature of about $5.5{\cdot}10^6$ K. During the observation, these places underwent a fast cooling: right down to the temperature of $2{\cdot}10^4$ K or somewhat less. The elements of the structure in Fig. 3 emit H_α radiation while the background still keeps its temperature of the order of 10^6 K. The three lower pictures in Fig. 3 show the Doppler shifts of the loop elements: the blueshifted parts as white and the redshifted ones as black. Scrutinizing these pictures, one inevitably concludes that the matter in both branches (or "legs") of a loop falls down - into the chromosphere. The explanation is: the cooling at the top of a loop increases the plasma density (the measured electron density has increased by the factor 3) and plasma, tracing the magnetic field lines, falls down due to of hydrostatic reasons.

It is worth noticing that such temperature regime and kinematics, characteristic of the "post-flare loops", do not apply to some other kinds of coronal condensations (e.g. "flaring loops").

The same post-flare loop event is presented in Malherbe *et al.* (1998) as a videotape. It is very instructive to see the motions and intensity changes along the loops. Notice an almost horizontal loop with one-directional motion along it (a flaring loop). It does not belong to the group of three vertical post-flare loops we have discussed here.

3. THE AGN CASE

3.1 Focusing on Seyfert Galaxies

Many galaxies exhibit some kind of activity which usually takes place in the galaxy core, namely in the AGN. An AGN has to satisfy at least some of the following conditions: 1) Radiation mostly originates in a compact nucleus, 2) There is a strong non-stellar continuum irradiated from the nucleus and emission spectral lines excited by it, 3) Both kinds of spectral features: continuum and the emission lines are variable in time, 4) Collimated jets from the nucleus are present, and 5) Extended radio lobes are developed.

Active galaxies can be grouped as follows: 1) Radio galaxies, 2) Quasars, 3) Blazars (BL Lac objects and "optically violent variables"), 4) Seyfert galaxies (Sy1 and Sy2 types), and 5) Low-ionization nuclear emission regions (LINERS) (Karas 1998).

In the present review we deal with AGNs of Seyfert galaxies only.

3.2 Spectrum of AGN

A very wide interval of wavelengths is irradiated from the AGN source: from hard γ to radio emission. Neutral and ionized emission lines are present. The last ones are found as Low Ionized Lines (LILs) and High Ionized Lines (HILs). As an a example, a part of the optical AGN spectrum of 3C120 is shown in Fig. 4.

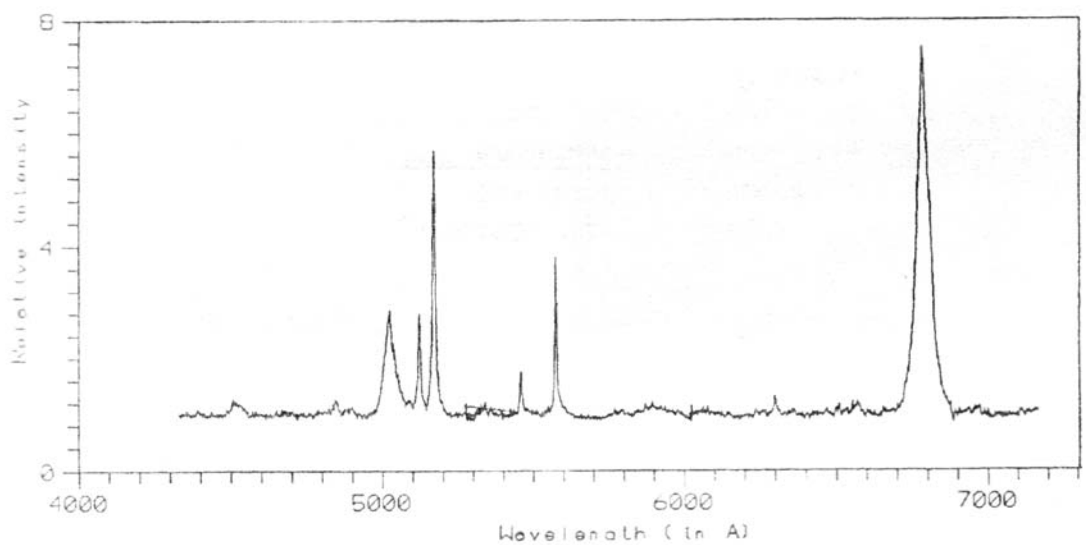


Fig. 4. *Spectrum of the galaxy 3C120 observed by K. K. Chuvaev at Crimean Astrophysical Observatory. From left to right, it shows the relative intensities of the redshifted spectral lines:* H_γ *(a very small peak),* H_β*, two narrow OIII lines, two weak telluric lines, and* H_α *(the strongest line). Notice the broad wings of the Balmer spectral lines.*

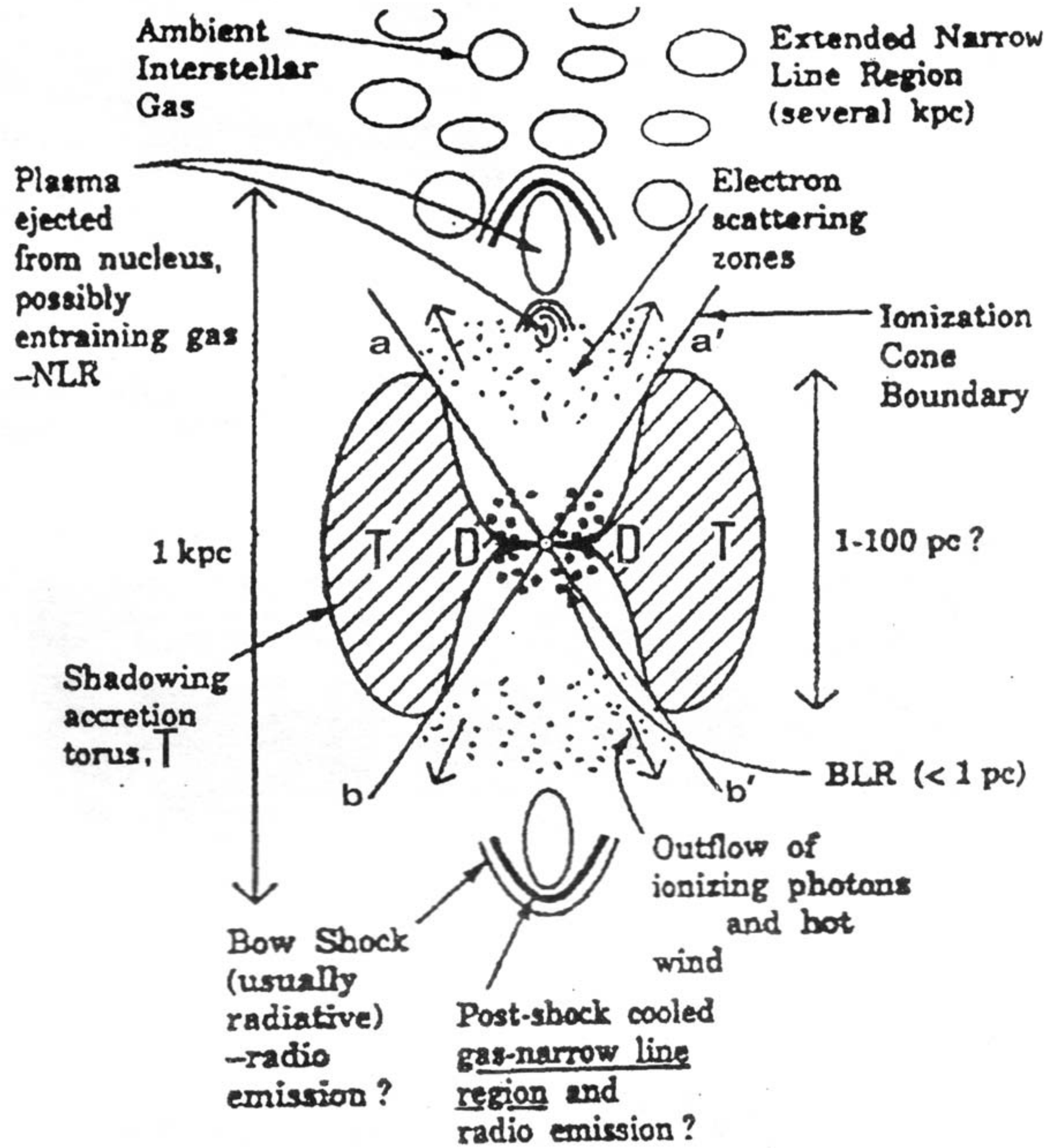


Fig. 5. *An axial (not-to-scale) cross-section of an AGN acording to Wilson (1997). The black hole, BH (white dot) is at the vertex of the ionization bi-cone (a-BH-a' and b-BH-b') defined by the free angular opening of the "shadowing accretion torus" (T-T). Here the torus is at its inner side extended to form the accretion disk (D-D) touching BH, according to Emmering et al., (1992). On each side of the acretion disk (above and below the line D-D) there is a BLR consisting of a greate number of broad line emitting clouds (black dots). The narrow emission spectral lines originate within the cones a-BH-a' and b-BH-b', at distances from about 100 pc to 1000 pc from the BH (the NLRs). Here the ionizing radiation from the vicinity of BH, plasma wind and plasma shocks propagate in the outward direction. At distances of about several kpc the matter coming from the AGN becomes mixed up with the galactic ambient gas.*

The unique property of AGN emission lines is their division into Broad Lines and Narrow Lines and, in some cases, their superposition. Balmer lines have a complex structure: they are composed of a narrow central component and of one or more broad ones. The shapes and variability of spectral lines indicates a complex structure of AGN. Moreover, we can add here time-variations of the radiation flux in the ionizing (X-ray and UV) and optical continua followed by correlated changes of the emission lines fluxes. The correlation time-lag exibits certain regularities (reverberation) and these constrain the size and structure of the corresponding emitting regions of an AGN.

3.3 AGN Structure and Kinematics

Various models were proposed to explain the observed complexity of AGN phenomena. In the first place a model has to account for an enormous energy production in, and irradiation from, an AGN. The total luminosity of an AGN can be in the range from 10^{38} erg s^{-1} to 10^{45} erg s^{-1}. Mainly, two concepts of the "central engine" in active galaxies have been proposed.

The Starburst Concept

There are circumstances when an unusually great number of very hot stars, so called "warmers", of temperature more than 10^5 K, appear near the galactic center. If earlier supernova explosions enriched that space with heavy elements, the star formation and the supernova events become even more frequent. The phenomenon is called "starburst". It fills the galactic center with hot stellar winds and strong X-ray, UV and optical radiation followed by already mentioned specific emission spectral lines. Wide-spread plasma and radio jets are launched around the rotation axis of the galaxy (Veilleux *et al.* 1996). A typical galaxy of this kind is M82.

The main phenomenological features of these galaxies are: the hot gas bubbles near the galactic center - where the starburst events take place, and very wide fan-like plasma jets usually seen as ejected from the galactic center away from the equatorial region of the galaxy.

The efficiency of energy production by the starburst mechanism is very low as it relies on stellar-type nuclear reactions. Only 0.1 per cent of the mass involved can be converted into the energy. The numerous stellar and supernova remnants cluster near the galactic center and consequently colapse into a massive black hole. For some time, of course, such a black hole might co-exist with the still active starburst in a galaxy like, for example, NGC 1068 and NGC 3079. In this sense some astrophysicists consider the starburst galaxies as an early phase in the evolution of an AGN that will eventually be powered by a black hole only. Such a galaxy, NGC 4945, as well as a galaxy-merger case, NGC 3256 (merging of two galaxies is supposed to trigger the starburst) have been analyzed by Moorwood and Oliva (1994).

Stellar collisions were suggested as an additional power source in a black hole AGN or even in a compound black hole+starburst AGN (Courvoisier *et al.* 1996). Namely, if a cluster of stars of a density of 10^8 solar masses per pc^3 surrounds a black hole, a direct collision of two stars per year, each releasing about 10^{52} erg, can provide a luminosity of 10^{45} erg s^{-1} - more than sufficient to maintain an AGN. The authors, under some assumptions, were able to produce an expected, quite realistic, light curve of a quasar.

The Black Hole Concept

The majority of AGN models are based on the existence of a massive (10^8 to 10^9 solar masses) Black Hole (BH) in the center of an AGN. The exotic property of a BH to exibit an irresistible gravitational attraction in its vicinity dictates the necessary elements of the model. The continuously infalling matter into the BH almost always have the form of a thin, plane accretion disk. At a typical distance of couple of parsecs the disk becomes thicker and eventually obtains the form of a large "doughnut", actually of a thick, cold, opaque, molecular, dusty torus, Fig. 5, (Wilson 1997). The accretion flow starts at the torus and spirals down toward the BH accelerating with approximately Keplerian velocities. The flow is expected to be turbulent and, approaching the BH, the velocities become relativistic. A recent Hubble Space Telescope record showing a dusty torus encircling a supermassive black hole in the eliptical galaxy NGC 7052 is shown in Fig. 6.

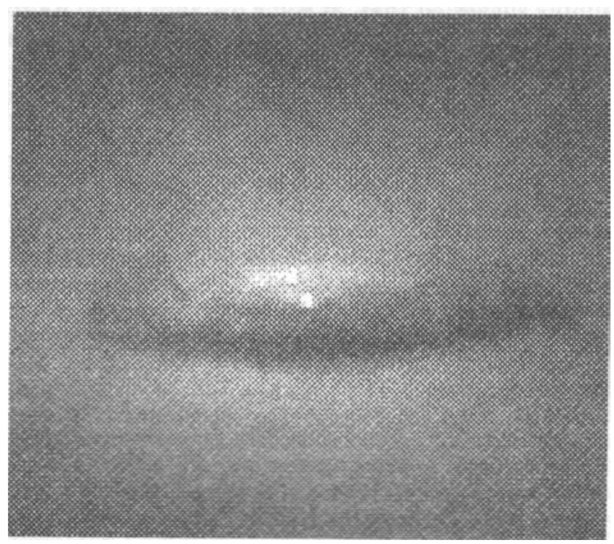


Fig. 6. *The black hole of $3{\cdot}10^8$ solar masses and the inner part of the accretion disk (bright) surrounded by a 3700 light-year-diameter dusty shadowing torus (dark) representing the AGN in NGC 7052 (according to Marel and Bosch, 1998).*

The immense gravitational energy is released in the inner part of the accretion disk: first, ionizing the disk and then, closer to the BH (at 4 to 6 GMc^{-2}), emitting very strong (10^{38} up to 10^{45} erg s^{-1}) ionizing radiation as well as propelling fast plasma jets and shocks along the axis of the accretion disk and plasma winds into the conical volumes around the axis.

In AGNs we look for the Balmer emission in two places: in the Broad Line Region (BLR) and in the Narrow Line Region (NLR). The BLR originates and irradiates at distances from about one light-day to about one light-month from the BH. In spite of a certain agreement on these figures among different authors, various shapes of BLR were proposed.

Some BLR Models

One of the popular models of BLR postulates an approximatelly spherical distribution of dense and cool (10^4 K) clouds embeded into the hot plasma environment around the central black hole. The cluster of black dots in Fig. 5 very roughly represent this idea. The clouds revolve around the black hole in Keplerian orbits of different sizes and randomly distributed obliquities (e.g. Wanders 1997). The model satisfies the observed profiles of broad spectral lines which indicate random motions - but not a large-scale inflow or outflow. Different parts of line profiles nicely correlate with the time-changes of the central source of ionizing radiations. However, the question of interaction of BLR clouds with the accretion disk remains open. Namely, how a diffuse object like a BLR cloud can penetrate the spiralling and turbulent accretion disk and emerge from the disk preserving its previous identity and Keplerian orbit?

An earlier model proposed by Collin-Souffrin (1987) does not invoke BLR clouds *at al.* It was simply suggested that, at some distance (3000 Rg to 4000 Rg; Rg being the Schwarzschild's radius) with suitable, radially decreasing temperature and electron density between 10^9 cm^{-3} and 10^{12} cm^{-3} in the accretion disk, the outer layers of the disk emit the spectral lines of low-ionized emitters (LILs) and, among them, the Balmer lines too. Apart from the central regions of the accretion disk where the released gravitational energy produces X-ray and UV ionizing radiation (as in all other black hole models) the accretion disk is stratified. The central layer depends only on the gravitational energy and at the mentioned radial distance can reach only about 1000 K and mainly emits an IR thermal continuum. The two medium layers receive some amount of scattered radiation from the central source, reach the temperature from 5000 K to 8000 K and emit LILs. The two thin outer layers receive the greatest amount of scattered radiation, become fully ionized and emit HILs. This model successfully describes widths of broad spectral lines and yields sufficient scattered radiation energy to photoionize HIL and LIL emitting layers of the accretion disk. The morphology and kinematics of the broad line emitting layers is simpler than in the case of BLR clouds.

In some AGNs the Balmer emission spectral lines, e.g. H_β, appear as double-peaked. It is always an indication of a revolution of the emitters around a center. In most cases, especially if orbital velocities greater than 5000 km s^{-1} are involved, the emission originates in connection with an accretion disk, at various distances from the black hole. But sometimes such a spectral line profile is interpreted as being emited from two separate BLRs connected with the two black holes orbiting around a common center of gravity (e.g. Gaskel and Sneden, 1997). The velocities are as a rule lower than 5000 km s^{-1} (Chen *et al.* 1989) and the wavelength separation of the two profile peaks must, frome time to time, periodically become zero. An example of this kind is the galaxy 3C390.3.

We review here a picturesque BLR model (Emmering *et al.* 1992), Fig. 7. Namely, the plasma within the accretion disk, still being neutral at the mentioned distances, moving along the accretion spiral orbits, can be ejected from the very surface of the accretion disk by the centrifugal force (probably modulated by violent turbulent velocity components). The ejected plasma obtains a cloud-like structure. Soon, illuminated by the strong ionizing radiation, some plasma species become ionized. They entrain some amount of the neutral hydrogen and, together, become directed by the magnetic field in the vicinity of the surface of the accretion disk. A photoionized ambient of hot corona (10^6 K) exists there. The plasma is highly ionized and free electrons are abundant. The extension of this corona is not known yet.

After leaving the surface of the accretion disk, the cool clouds heat up and their ionization takes place depending on the intensity of the ionizing radiation. Soon, the cooling processes - conductive and radiative - begin. The last one is very effective and, as the temparature gets to about 10^4 K, the recombining hydrogen atoms emit the Balmer emission lines. They are broad due to various line-of-sight velocities of the emitters and because of their radiation being scattered on the fast free electrons. The thickness of the BLR depends on the emitting clouds' average life-time. For example, Bottorff *et al.* (1997) estimate that BLR clouds reach the "diskocentric equatorial latitude" of about 30^o. The clouds are probably destroyed by evaporation, intrinsic instabilities and collisions as they head away from the accretion disk surface (Emmering *et al.* 1992).

This model was seriously criticized by Done and Krolik (1996) mainly for not yielding satisfactory random motions which would correspond to their very detailed analysis of the responses of various parts of the observed spectral line profiles to the changes in intensity of central ionizing radiation source. However, no explicit alternative AGN structure has been suggested.

Another place in an AGN where one finds Balmer lines is NLR. Two NLRs are situated within the frames of the two ionizing cones shown in Fig. 5. In both cones the high mean temperature (10^6 K) highly ionized, highly accelerated plasma flows outward from the common vertex, the BH. The plasma axial velocities of more than 500 km s^{-1} are typical for the vicinity of the BH while, after several kpc, the motion slows down to the velocities of the ambient galactic gas. Somewhere in between, photoionization with some contribution of plasma shocks (and with the post-shock cooling) are sufficient to excite hydrogen to emit the Balmer lines. So again, in NLR

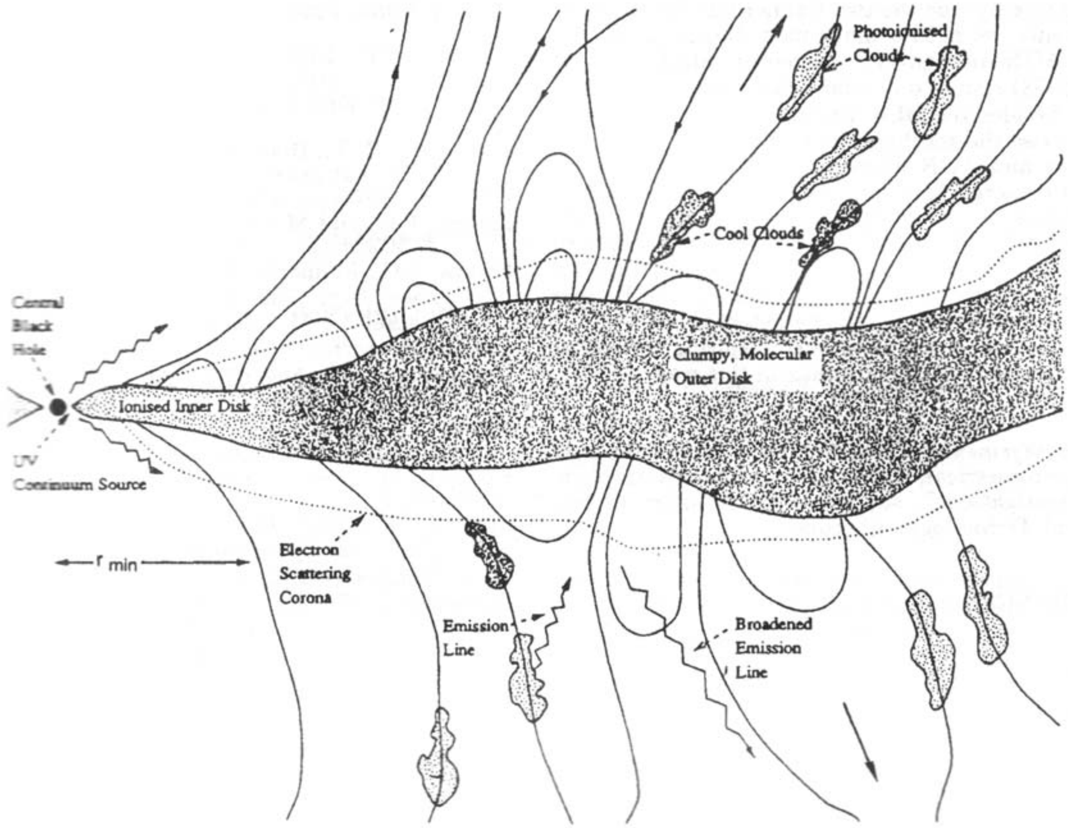


Fig. 7. *One-side cross-section of an accretion disk according to Emmering et al. (1992). The wiggly, shaded band represent the warped, turbulent accretion disk, ionized near the black hole (at the left) and neutral, even molecular, at large radial distances (at the right). The broad line emitting clouds, cool and then photoionized, escape from the disk along the magnetic field lines. Their radiation emitted toward the disk scatters in the electron scattering corona near the disk surface contributing to still further broadening of the spectral line profiles.*

the hydrogen atoms, cooled to about 10^4 K, are surrounded by a very hot corona with the temperature of about 10^6 K or more.

4. CONCLUDING REMARKS

The parallel look at the two objects distant in space and time, of stellar and galactic scale, the Sun and an AGN, has focused our attention on the cool components of some types of solar coronal condensations and BLRs in AGNs. Two plasma pressure equilibrium states, followed by the corresponding atomic ionization states and spectra, are found in both cases. Balmer spectra of the two objects differ by amounts of line-emitted energy and line profiles, caused by different overall production and irradiation of energy in them, as well as by the specific dynamics of the two emitting regions. The local plasma conditions in the Sun, especially the dynamics, are within the reach of direct observations. The detailed mechanism of local triggering the 10^6 K to 10^4 K transition is on the way to be understood (Forbes and Malherbe 1986; Forbes *et al.* 1989). The crucial elements of the models are: the presence and activity of magnetic fields (reconnection of magnetic field lines) and a kind of chromospheric evaporation.

On the other hand, there are no agreements of researches on the shape and dynamics of BLRs in AGNs. We can take as certain that the size of a BLR is about one light-month and that the motions within BLRs (clouds or some other forms) contribute to the broadening of Balmer spectral lines. Sometimes, the magnetic fields were mentioned only in general terms. It is belived that the global magnetic field around an AGN is modified by the motion of the accreting matter: the field is being compressed and enhanced toward the black hole. Only recently the magnetic reconnection process has been invoked to explain a kind of flare-like events in AGNs and the heating of accretion disk coronas by a coronal loop mechanism (Di Matteo 1998). It is further established that the magnetic field dictates the motion of plasma near the central AGN engine directing the hot plasma jets up to great distances along the accretion disk rotation axis.

In order to complete our mind experiment of putting side by side the two Balmer line emitting environments, we need a much more thorough picture of the AGN-mechanism. Moreover, after Di Matteo's (1998) results our solar-AGN parallel considerations, besides the BLR aspect, should be extended to comprise the mechanisms that trigger and power the solar and AGN flares as well as the process of magnetic energy transport from "lower" layers into the coronas. As far as the solar corona is concerned, we suggest to observe the next total solar eclipse of August 11, 1999 with the aim to look for some locations (perhaps of a larger scale) where the Balmer emission, mainly H_α, might be detected.

Anyway, it has been very inspiring to look at the solar and the AGN coronas in this way.

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КОЕГЗИСТЕНЦИЈА ДВЕЈУ ФАЗА ПЛАЗМЕ У СУНЧЕВОЈ И АГЈ КОРОНИ

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Прегледни рад

Паралелно се разматрају два далека космичка објекта, Сунце и активна галактичка језгра (АГЈ), где се неутрални водоник појављује у вези са топлим коронама. Осим Сунчеве фотосфере, хромосфере и протуберанаца где је присуство неутралног водоника поуздано установљено, његова емисија високо у топлој Сунчевој корони је још у извесној мери загонетна. Даје се преглед неких ранијих посматрања када је H_α емисија у корони детектована приликом потпуних Сунчевих помрачења или при свакодневним коронографским посматрањима. Још не постоји једно генерално теоријско тумачење појаве емисије хромосферског типа у топлој корони. На другој страни, слична емисија водоника присутна је и у АГЈ. Ова област астрофизике се данас интензивно развија. Овде скицирамо неке моделе АГЈ који су од актуелног значаја у астрофизици.