PART III

UV ASTRONOMY

A. NEW RESULTS

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RESULTS OF ASTRONOMICAL STUDIES IN THE FAR UV REGION

V. G. KURT
U.S.S.R. Academy of Sciences, Moscow

In this survey I shall discuss only the results of studies which were obtained with instruments of moderate spectral and spatial resolution. The use of such instruments allows for the study of extremely weak fluxes in the UV region which are unaccessible to diffraction spectrometers of high resolution. In addition a broad field of view dispenses of strict attitude control system. Apparently, investigations of this kind are to be related to a study of sky background, including stellar and non-stellar components, and also to observations of planetary atmospheres from spacecraft in a near fly-by (Earth, Venus, Mars). Results obtained so far are impressive. It would be sufficient to say that due to UV observations the upper atmosphere of Mars has been studied for the moment with the same precision as that of Earth about 15 years ago

1. Stellar Component of Sky Background

For recent years studies of stellar components of heavenly background in the far UV region of the spectrum have been carried out by many authors. For such observations photometers with a field of view from 0.5 deg up to several tens of degrees with a spectral resolution of 20–100 Å were used. First UV emission from celestial sources was registered with the use of photon counters sensitive in the region $\lambda = 1230$–1350 Å as early as in 1955 (Byram *et al.*, 1957; Kupperian *et al.*, 1958a, 1958b). Similar observations carried out in a region involving the line Ly-α allowed to detect an extended hydrogen glow of the Earth and more than 100 papers were dedicated to its investigation. Geocorona observations were carried out from rockets, artificial earth satellites (AES) and from automatic interplanetary stations (AIS), however, glow observations and Ly-α emission theory are pertinent rather to the geophysics than to the astronomy.

Measurements of pure celestial background free of the earth-atmospheric glow effect were carried out by the author with the use of instruments carried on board of five 'Venera' AIS outside of the Geocorona (Kurt, 1967; Kurt *et al.*, 1968b). However, observations outside of the Ly-α line in night conditions are possible also with AES and rocket borne instruments. The comparison of data of different authors is difficult due to possible errors in absolute measurements. In spite of the numerous techniques of instrument calibration (high efficiency ionization chambers, vacuum thermocouples, electron emission under Cherenkov radiation and synchrotron radiation) errors of a factor two or three cannot be excluded. For instance, simultaneous background measurements carried out from Venera 4 and Mariner 5 differ by a factor of two. At the same time the relative precision of the measurements is 10–30%. In a paper (Belajaev *et al.*, 1970) measurements outside of the Geocorona

Labuhn and Lüst (eds.), New Techniques in Space Astronomy, 219–232.

were carried out in three spectral ranges: $\lambda = 1050–1180$ Å with the field of view of 13 deg; $\lambda = 1050–1340$ Å and $\lambda = 1225–1340$ Å with the field of view of 0.7 deg. In the wavelength range shorter than Ly-α the brightness changes depending on the instrument attitude between $(3–65) \times 10^{-8}$ erg/cm^2 s ster Å whereas observations in the range $\lambda > 1216$ Å gave $(2–45) \times 10^{-9}$ erg/cm^2 s ster Å. The observations show notable correlation with a galactic latitude which allows to attribute the emission to a stellar background. Similar measurements were carried out by a group of Japanese scientists (Hayakawa *et al.*, 1969; Yamashita, 1968) with the use of photon counters on board of a high altitude rocket. In the range of $\lambda = 1350–1480$ Å they scanned a sky region near the galactic plane for $l^{II} = 190$ deg where maximum of intensity was 6×10^{-7} erg/cm^2 s ster Å with a field of view of 5 deg in diameter (Figure 1). In the

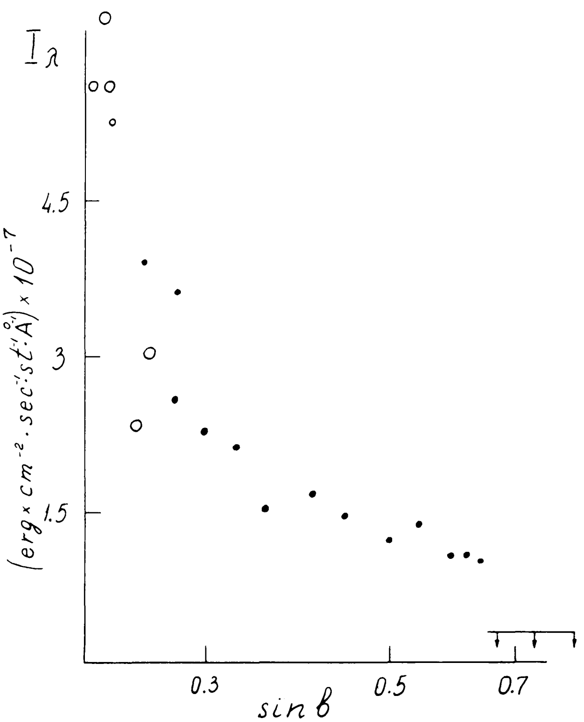

Fig. 1. Dependence of intensity of UV emission in the range $\lambda = 1350–1480$ Å from a galactic latitude according to data (Hayakawa *et al.*, 1969) (solid circles) and data (Belajaev *et al.*, 1970) (open circles) and measurements with an unknown orientation.

range of galactic latitudes from 20 to 40 deg the observable brightness is well approximated by the secant low of galactic latitude. One may indicate for this measurements an upper limit of intensity for a non-stellar component of 10^{-8} erg/cm^2 ster s Å for $\lambda = 1050–1180$ Å and 7×10^{-9} for $\lambda = 1225–1340$ Å according to (Belajaev *et al.*, 1970) and 1.7×10^{-8} for $\lambda = 1350–1480$ Å according to data from (Hayakawa *et al.*, 1969).

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Further on I shall discuss the significance of these results and possible prospects of background measurements up to 10^{-10} or 10^{-11} erg/cm^2 s ster Å.

Stellar background observations in the far UV region of the spectrum has an interesting peculiarity in comparison with observations in the visible and near UV regions:

(a) a small number of stars in the field of view of less than 100 square deg give the major contribution to the observable brightness;

(b) strong interstellar dust absorption limits the region of observation to within 100–200 ps.

A similar analysis of this problem is contained in paper (Smirnov, 1970) where the intensity of the stellar emission giving the major contribution in a detector with a field of view Ω is calculated. The observable intensity is given by the equation

$$I = \frac{1}{\Omega} \sum_{Sp} \sum_{i} N(\mathrm{Sp}, R_i)\, \mathscr{L}_\lambda (\mathrm{Sp}, R_i)\ \mathrm{erg/cm^2\ s\ ster\ Å}, \tag{1}$$

where $N(\mathrm{Sp}, R_i)$ is a number of stars of a given spectral type at a distance R_i from the Sun; $\mathscr{L}_\lambda(\mathrm{Sp}, R_i)$ is an observable intensity of UV emission of the star of spectral type Sp at a distance R_i. The summation in (1) is over all spectral types of stars beginning from a distance R_j closer of which there is no star which enters in the field of view with the probability of $\frac{1}{2}$. The assumption was made that the star density in the galaxy $D(\mathrm{Sp})$ drops with an increase of galactic latitude b according to an exponential law

$$D(\mathrm{Sp}, R) = D_{Sp} \exp - \left\{ \frac{R \sin b}{H_{Sp}} \right\} \mathrm{ps}^{-3}, \tag{2}$$

where D_{sp} is the stellar density in the galactic plane; H_{sp} is a scale height for stars of a given spectral class in parsec.

Taking into account of an interstellar dust absorption we have

$$I_\lambda = \sum_{Sp} |\ 10^2 \mathscr{L}_\lambda (\mathrm{Sp})\, D_{Sp} \int_{R^*(\mathrm{SP}, \Omega)}^{\infty} \exp\left\{ - \tau_\lambda (R) - \frac{R \sin b}{H_{Sp}} \right\} \mathrm{d}R, \tag{3}$$

where the low limit of integration R^* is found from the condition that a probability of finding a star in the field of view is equal to $\frac{1}{2}$:

$$\Omega\, 3 \times 10^{-4} D_{Sp} \int_0^{R^*(\mathrm{SP}, \Omega)} \exp - \left\{ \frac{R \sin b}{H_{Sp}} \right\} R^2 \mathrm{d}R = \tfrac{1}{2}.$$

The optical depth of dust is $\tau_\lambda = a_\lambda R$ where a_λ is in average equal to $(2\text{–}5) \times 10^{-3}$ ps^{-1} for $\lambda = 1115$ Å (Bless *et al.*, 1968) and changes slowly in a range of several hundred Angströms. Figure 2 shows the mean density of stars in the galactic plane according (McCuskey, 1956) for the galactic longitudes of 45 and 130 deg. Intensities of UV emission of stars O5, B0, and B4 were calculated by Morton, Adams and Hickok on the basis of rocket spectrograms (Hickok and Morton, 1968; Adams and Morton, 1968) and, it seems, they agree well with new data obtained from the orbital astronomical observatory (OAO).

In Figure 3 the most probable value of the brightness as a function of the field of view is shown. In the same figure the mean dispersion from a mean intensity is shown.

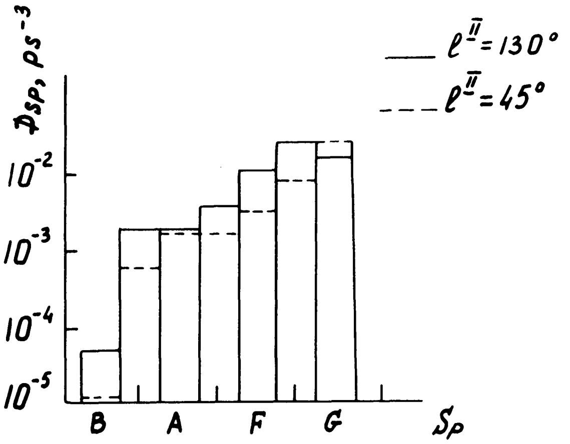

Fig. 2. Density of stars of different spectral class in the solar vicinity.

Our measurements and data of Japanese authors show good agreement with conventional models of star and dust distributions in the solar vicinity.

According to the above mentioned results for observations near the galactic plane with the fields of view of 1–10 square deg the major contribution is given by stars of B 2–B 7 spectral types and for the smaller fields of view (10^{-1}–10^{-2} square deg) it is given by B 7–A 2 stars. At high galactic latitudes, as the field of view decreases, a contribution of stars of latest spectral classes increases. So, for instance, for a field of view of 10^{-2} square deg an observable intensity is determined mainly by stars of type G.

It is obvious that in the visual range of the spectrum a large contribution is made by weak stars of latest spectral types which strongly diminishes the most probable brightness from a field of view. The decrease of absorption at interstellar dust leads in the same direction. Figure 3 shows theoretical curves and also results of measurements from (Belajaev *et al.*, 1970) and (Hayakawa *et al.*, 1969).

2. Background Observations in the Ly-α Line

The existence of extraterrestrial component of Lyα emission was detected in the experiment by Morton and Parcel that used a hydrogen cell with an absorption band of 0.08 Å. Presence of emission outside of this band indicated a high temperature of the scattering atoms of hydrogen ($\gtrsim 10^4$ K) that excluded its geocoronal localization. A possibility of doppler shift due to Earth movement ($\Delta\lambda = 0.12$ Å) was excluded because of the absence of a sharp asymmetry of the observable pattern at the apex of Earth orbital movement. Shortly after this Johnson, Patterson and Hanson (Johnson *et al.*, 1963) explained the neutral hydrogen emission of 10^6 K by charge exchange of

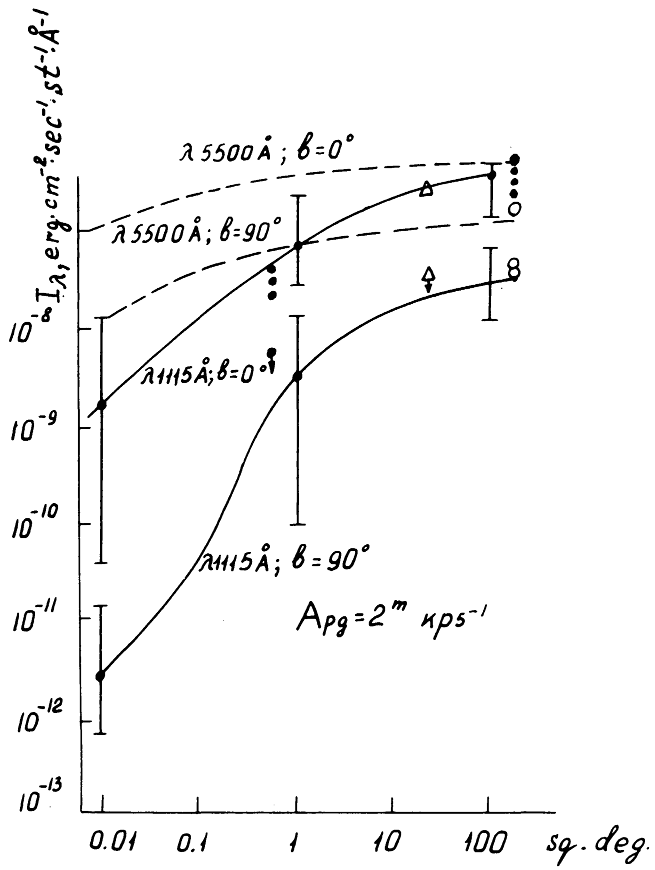

Fig. 3. Comparison of results of UV background measurements with theoretical curves: intensity as a function of field of view for $b^{II} = 0°$ and $b^{II} = 90°$. Dashed line represents the intensity in the visible part of spectra for $b^{II} = 0°$ and $b^{II} = 90°$ for an absorption $A_{pg} = 2^m$ kps^{-1} (circles (Belajaev *et al.*, 1970), triangles (Hayakawa *et al.*, 1969)).

solar wind protons with neutral interstellar hydrogen. Under this assumption the anisotropy of the Lyα emission was naturally explained. The explanation of the observable intensity (about 2×10^{-4} erg/cm^2 s ster) required a concentration of 'hot' atoms about $10^{-2} - 10^{-3}$ at/cm^3 in a sphere with a diameter of some ten astronomical units. Besides the hot atoms the model by the three authors include 'cold' ($T \sim 10^2$ K) hydrogen atoms the density of which quickly drops due to ionization as one approaches the Sun.

For the first time direct measurements outside the geocorona were carried out by the author in 1964 on the probe Zond 1 (Kurt, 1965). The measured intensity of Lyα emission agreed well with the data of Morton (15% from geocorona intensity). During 1964–69 we carried out such measurements at five interplanetary Venera probes. The experiments had given a concentration of Ly α emission to the Milky Way although this observation did not cover all the sky. According to data obtained from probes Venera −2 and 3 during a scan along a small circle an increase (15–30%) of the signal was noted when crossing the galactic equator. Observations from the probe Venera 4 (Kurt *et al.*, 1968b) show an existence of one extended maximum near the galactic equator two times brighter than regions at high galactic latitudes. Measurements at Venera 5 and 6 probes (Belajaev *et al.*, 1970) with a field of view of 0.7 deg also confirm earlier noted minimum for five points near $l^{II} = 300$ deg in a range of the galactic latitudes from −7 to −12 deg. A ratio of maximum intensity to minimum according to these measurements is not smaller than an order of magnitude.

During five years one can note some changes related apparently with the solar activity. The later consideration argue against a stellar nature of the detected effect. Analogous measurements carried out at the OGO 3 spacecraft (Mange, 1968) from distance of 20 Earth radii did not show the brightness effect when crossing the galactic equator. Results obtained by Barth from Mariner 5, 6 and 7 are very difficult to compare (Barth, 1969b; Barth, 1970) since in the first experiment a photometer with a broad spectral band (1050–2200 Å) including Ly-α line was used. When scanning the sky a very weak gentle maximum near to the galactic equator. The most reliable results were obtained with the use of a diffraction spectrometer with a resolution of 20 Å carried by Mariner 6 and 7. With the use of this instrument with field of view 0.23×2.3 deg a brightness in the Ly-α line was measured in several regions of the sky. The measurements showed a scattering of mean intensity from 200 to 500 Rayleigh without a noticeable correlation to the galactic equator.

Blamont's measurements (Bertaux and Blamont, 1970) carried out at the OGO 5 satellite do not give a clear reply to the question whether there is a galactic component. According to these observations which were carried out from a distance of 6 Earth radii in spectral range of $\lambda = 1175–1255$ Å with a hydrogen absorption filter of width 10^{-2} Å this is probably a uniform background with an intensity of 200 Rayleigh and a variable component of 0–130 Rayleigh. Absolute values of these measurements are in good agreement with our experiments and are approximately two times less than those of Barth from Mariner 5 data (550 Rayleigh).

Entirely new results were obtained by an experiment of the Vela spacecraft by a group of authors from Los Alamos Laboratory (Chambers *et al.*, 1970). In this experiment an UV detector oriented permanently into zenith scanned a big circle in the sky. In doing so an extended maximum near the Sun apex was detected (Figure 4). Such picture corresponds to a modified model by Johnson, Patterson and Hanson (Johnson *et al.*, 1963) that take into account a motion of the Sun into the interstellar media with a velocity of 20 km/s.

A theoretical analysis of the problem of charge exchange of solar wind protons with neutral atoms of interstellar medium is given in works by Fahr *et al.* (Fahr and Blum, 1970; Blum and Fahr, 1970; Blum and Fahr, 1969). These models deal also with the two components of neutral hydrogen atoms: 'hot' one which arises in the process of change exchange of solar wind protons and 'cold' one which consists of atoms of the interstellar medium. At the idealized picture due to a path curving into a

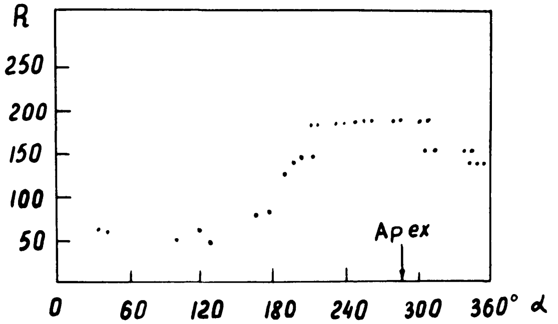

Fig. 4. Intensity in Ly α emission far from the Earth according to data (Chambers *et al.*, 1970) as a function of a right ascention along the orbit.

gravitational field of the Sun a focus of cold atoms in the anti-apex is obtained. According to the Fahr model we must have at the sky two maxima: the first one in the apex and the second in the anti-apex and in addition the first one must be larger by an order of magnitude. Observation (Chambers *et al.*, 1970) apparently correspond to this model. However, our measurements on five spacecrafts and also Blamont's OGO 5 and Barth's Mariner 6 and 7 observations do not show an increase of brightness during the approach to the solar apex. In addition the intensity obtained in the experiment is five times lower than data of Mariner 6 and 7 and by two or three times lower than in our measurements.

Summing up one may say that numerous measurements made by ten spacecrafts do not solve the problem of extra-geocorona Ly-α background. We may only state that there exists a more or less isotropic background with an intensity of 100–500 Rayleigh which is covered with a non-isotropic component. There are indications that this pattern changes slowly depending on the solar cycle. As far as the relation of the non-isotropic component with the galactic plane or with the apex of solar movement into the interstellar medium is concerned these data need to be carefully proved by experiments.

In relation with the problem discussed one should mention the very interesting data obtained by Blamont at the OSO 5 spacecraft in 1969. He used an instrumentation consisting of a diffractional monochromator and two gas filters filled with hydrogen and deuterium which absorbs emissions in a band of 10^{-2} Å near the lines Ly-αH I and Ly-αD I with wavelengths $\lambda = 1265, 664$, and 1215, 334 Å (Blamont and Vidal-Majjar, 1970). Measurements carried out at an altitude of 550 km during the whole year 1969 showed that the integral flux in the line changed by 20 per cent whereas the intensity in the center of the line changed by more than 100% with a good correlation to the solar activity. At the same time the intensity in the 'blue' wing of the line at a distance from the center of 0.3 Å changed only by 10%. Certainly a portion of the change in the center of the line is related to variations of the hydrogen concentration in the geocorona at heights of 550 km.

One of the plausible explanations of such a strange picture of background behaviour in the line Ly-α outside of the geocorona may be the interaction of solar wind with a galactic magnetic field due to which the spread of hydrogen along field lines occurred (Kurt and Sunyaev, 1967a). In this case it is difficult to understand a correlation of the direction of field lines of the galactic magnetic field with the plane of the Milky Way inside the solar system. By this assumption the temporal variations of intensity of a dispersed Ly-α emission in the interstellar medium is well explained. (See note added in proof, p. 231.)

3. Prospects of UV Study of the Celestial Background

Observations of the celestial background in the UV region of the spectrum enable to solve other problems of stellar and interstellar astrophysics. This side of the interpretation was discussed in details by Sunyaev and the interpretation was discussed in details by Sunyaev and the author at the *IAU Symp.* 36 (Kurt and Sunyaev, 1970). The separation of a non-stellar background component is of main importance.

An isotropic emission of intergalactic nature can be a direct argument for the existence of a hot intergalactic gas. Such emission in a range of λ greater than 1216 Å arises due to the cosmologic red shift of the Ly-α Line emitted by an intergalactic gas. At a temperature of 10^4–5×10^4 K the intergalactic gas will emit mainly the Ly-α line by electron impact and recombination (Kurt and Sunyaev, 1967b). In this case a major contribution in the range of $\lambda = 1225$–1340 Å would be due to the methagalactic region near $Z=0.1$ ($Z=\Delta\lambda/\lambda=$red shift). At a temperature of 5×10^4–5×10^5 K the major contribution in this range would be due to the line of ionized helium at $\lambda=304$ Å emitted by a region with substantially large Z (3–3.5). So in the range of temperatures of 10^4–10^6 K the UV observations are very effective. However, to exclude a density higher than the critical one ($\varrho_{\text{Crit}}=2\times10^{-29}$ g/cm^3) in the whole range of temperature one should fix an upper limit of the non-galactic component at 10^{-11} erg/cm^2 s ster Å. A minimum of intensity under this condition corresponds to the temperature about 6×10^5 K. This quantity is by 10 less than modern evaluations (Belajaev *et al.*, 1970; Hayakawa *et al.*, 1969) but there are real prospects to reach such a sensitivity. A stellar background fluctuation analysis (Smirnov, 1970) shows that at higher galactic latitudes for a field of view less than 0.1 square deg the above mentioned flux could be detected with a mirror of 30–50 cm diameter with a time constant of 300 s and a decrease of background pulses by charged particles to a quantity about 0.1 imp/s. However, it would be yet great success to reach a quantity of 10^{-10} erg/cm^2 s ster Å.

In the spectral range under discussion could fall also an emission in the Ly-α line of neutral atoms of interstellar medium having energies from 26 keV to 100 keV. Such atoms are produced by charge exchange of low energy cosmic rays with neutral hydrogen atoms of interstellar medium. The charge exchange process leads to a considerable number of atoms in an excited state which emit very shifted quanta into the Ly-α line. Quick neutral atoms could also be excited by collision with slow atoms of interstellar medium. To single out this component is associated with the same diffuculties as to single out the intergalactic gas emission. However, to obtain an upper bound of energy of cosmic rays a soft region where direct measurements are impossible would be of prime importance. For the time being this quantity may be avaluated due to measurements (Kurt and Sunyaev, 1968; Belajaev *et al.*, 1970 and Hayakawa *et al.*, 1969); it is $W \lesssim 10^{-2}$ eV/cm^3 for the energy range of 26–100 keV.

4. Planetary Study

Study of planets in the UV region could give answer to the structure of their atmospheres which is especially important for the determination of gases which have no lines in the visual part of the spectrum (Barth, 1969a). Spacecraft observations could include a study of solar radiation reflected by the surface as well as the atmosphere emission (dayglow, nightglow and twilight). At first absorption lines are studied later emission lines. It is obvious that an analysis of absorption spectra is more complicated than that of emission lines since in a process of formation of absorption lines one should take into account reflection from the surface, scattering in the atmosphere and in a cloud layer, etc. The problem of the density calculation for resonance scattering by atomic gas is a simple one. For an optically thin atmosphere the observable intensity is

$$I(R) = \frac{1}{4\pi} \int_{\lambda} \int_{R} (\pi F_{\lambda})_S \, n(R) \, \sigma_{\lambda} \mathrm{d}\lambda \mathrm{d}s \ \mathrm{erg/cm^3 \ s \ ster \ Å} \tag{5}$$

where $(\pi F_{\lambda})S$ is the solar emission intensity (erg/cm^2 s Å); σ_{λ} is the scattering cross-section; ds is an element of path of integration.

Taking only into account the Doppler core and assuming that the Doppler width of the scattering line is much less than that of the solar emission line we have.

$$I(R) = \frac{1}{4\sqrt{\pi}} \pi F_s \sigma_0 \Delta\lambda_{\mathrm{D}} \int_{R}^{\infty} n(R) \, \mathrm{d}s \,. \tag{6}$$

Integral calculation in (6) leads to the solution of a Van Rein problem depending on the form of the function $n(R)$ and the angle between the line-of-sight and the direction to the planet center. This problem was considered in (Barth, 1969a; Kurt, 1967) for the cases

$$n(R) = n(R_0) \left(\frac{R}{R_0}\right)^k \qquad \text{and} \qquad n(R) = n(R_0) \exp\left(-\frac{h}{H}\right) \tag{7}$$

for zenith and horizon observations. In the work (Kurt, 1967) a problem for an arbitrary angle and for integer values of k in (Hord *et al.*, 1970) was solved.

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An account of non-zero optical depth of the atmosphere leads to the necessity of solution of a transfer equation in a three-dimensional medium. Accounting for the shape of the planet and effective absorption is complicated and in general an unsolvable problem. However, an approximate account of a high order scattering could in some cases be done with a desirable accuracy. For example, an account of planet back scattering could be done (Wallace *et al.*, 1969) by introducing into the expression (Belajaev *et al.*, 1970) of the surface brightness a factor $[1 + A(R_0/R)^2]$ where A is the albedo and is according to (Kupperian *et al.*, 1959) for the center of a line in night conditions equal to 0.4–1.0. For greater optical depths solutions of the transfer equations were obtained in (Thomas, 1963; Donahue and Thomas, 1963; Kaplan and Kurt, 1965) in a power expression of the dependence of atomic hydrogen density from distance.

A study of resonance scattering of solar Ly-α emission was carried out for Earth, Venus and Mars. Earth hydrogen glow observations extend up to 120000 km, that is up to 20 Earth radii (Kurt, 1967; Barth *et al.*, 1970). It is simply impossible to list all works carried out from satellites. In Figure 5 a distribution of atomic hydrogen

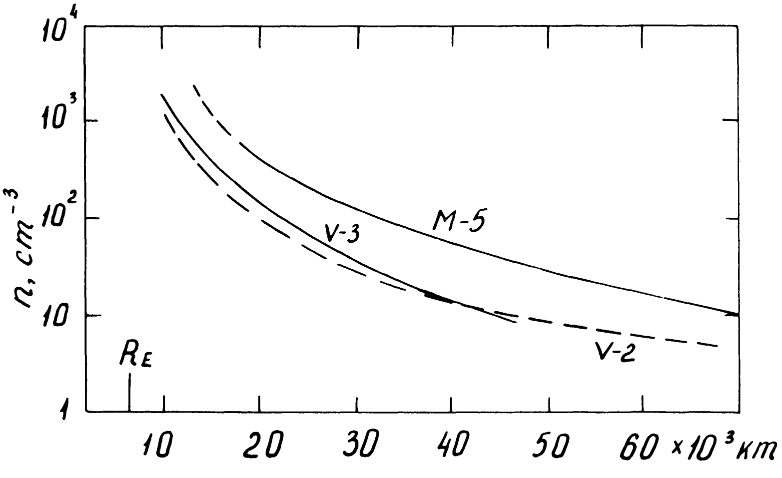

Fig. 5. Density of atomic hydrogen in the geocorona at large distances from the Earth.

according to Venera 2 and 3 and Mariner 5 data for great distances (several thousand kilometer) are given. Systematic differences between our data and that of Mariner 5, accounted for by differences in an absolute calibration of detectors, were already pointed out. Observation in the geocorona are explained fairly well by the theory of dissipation of atomic hydrogen.

In October 1967 with the help of instruments carried by Venera 4 and Mariner 5 spacecraft a hydrogen glow of Venus was discovered (Kurt *et al.*, 1968a; Barth, 1968). A detail analysis of these observations carried out by Wallace (Wallace, 1969) shows that a simple theory of hydrogen dissipation does not account for the observable intensity run in Ly-α emission as a function of height. At great heights (more than 20000–30000 km) an agreement of our data with that of Barth is sufficiently good (Figure 6). A systematic difference is accounted for by a difference in the absolute reference since background level far from the planet was different by the factor 2 (250 and 500 Rayleigh accordingly). As concerns Mariner 5 measurements near the planet the intensity run is not accounted for by a simple theory of atomic hydrogen dissipation. The best agreement according to (Wallace, 1969) data is reached in a combined model with a high abundance of deuterium by 10^6 higher than that at the Earth. It is well-known that a hydrogen dissipation causes an enrichment of the exosphere with deuterium since hydrogen dissipates more quickly but such a difference in the concentration

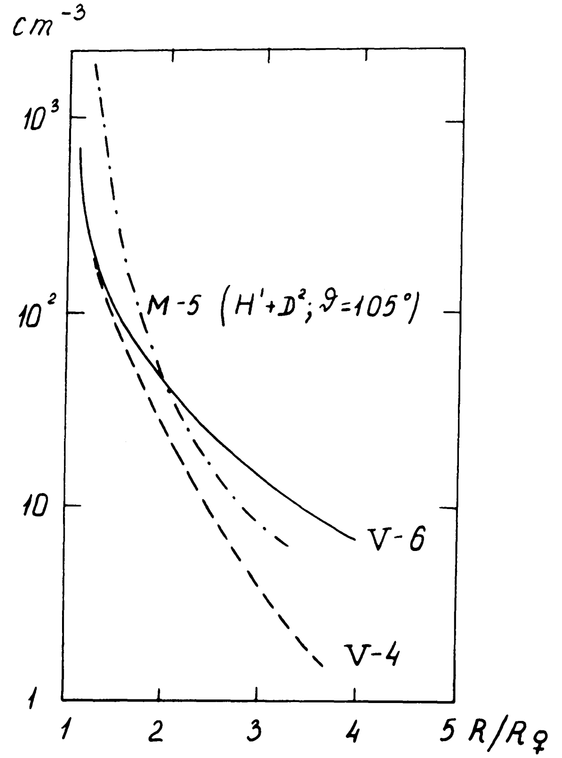

Fig. 6. Density of atomic hydrogen in the exosphere of Venus.

awakes a suspicion to the correctness of this interpretation. We should concentrate our attention at the construction of a theory which would take into consideration a horizontal transfer of hydrogen atoms from the dayside to the nightside of the planet. A direct check of deuterium presence in the Venus exosphere could be realized according to a technique proposed by Blamont with use of hydrogen and deuterium cells.

Observations in the lines of atomic oxygen $\lambda = 1304$ Å in Venus did not detect its

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presence with a concentration larger than 2×10^3 cm^{-3} for the altitudes of 300–400 km. In the case of oxygen the distribution of which is decribed by a barometric equation with a scale height of H the number of atoms on the line-of-sight to the horizon is equal to $N_0\sqrt{(\pi R_0 H/2)}$, where N_0 is a concentration at the level of observation and R_0 is the radius of the planet. When the spacecraft is outside the atmossphere this quantity must be multiplied by two, and N_0 should be understood as a concentration at a minimum distance R_0 along the line-of-sight from the center of the planet. All this is correct for an optically thin atmosphere.

Observations near Venus were carried out with photometers since with the exception of atomic hydrogen and oxygen the presence of other atoms is not expected.

In a fly-by near Mars of Mariner 6 and 7 spacecraft observations were carried out with the use of a diffraction spectrometer with a resolution of 10 and 20 Å (Hord, 1970; Stewart, 1970; Barth *et al.*, 1969) in the region $\lambda = 1100$–1900 Å. On several hundred spectra obtained in the fly-by near the planet, emission lines of atomic hydrogen (H I $\lambda = 1216$ Å), triplet of atomic oxygen (O I $\lambda = 1304$ Å), and also bands CO, CO_2^+, and lines of atomic oxygen near 2972 Å (Figure 7) were registered. On the

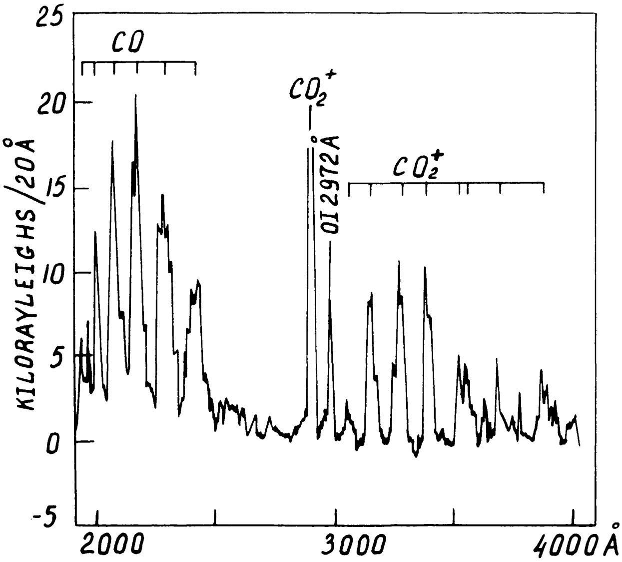

Fig. 7. UV spectrum of Mars atmosphere for observations near the horizon for the range $\lambda = 2000$–4000 Å.

base of this data a model of the upper atmosphere of Mars was constructed by the authors. The Mars atmosphere is transparent up to 1970 Å that could have great consequences in connection with the problem: "Is life on Mars?"

A hydrogen glow of Mars was traced up to 25000 km, where Lα-emission only very slightly exceeds the interplanetary background. Atomic oxygen $\lambda = 1304$ Å emission is noticeable below 300 km, however, the abundance of atomic oxygen does not exceed much that of the Earth's atmosphere. The Mars exospheric temperature is half that of the outer Earth Atmosphere. Absence of N_2 and N_2^+ emissions allows to determine an upper boundary of molecular nitrogen abundance in the Mars atmosphere at about 1%. Bands of O_2 were also not discovered.

In a mission of the Orbital Astronomical Observatory (Sagan, 1970) some data on UV emission of Venus, Mars, Jupiter and Saturn were obtained. On the base of the spectra upper limits for some gases were calculated and an ozone content in the Mars atmosphere was determined.

In a program of future planetary studies we see the detection of inert gases and first of all the determination of the argon abundance which should be high due to potassium radioactive decay. Unfortunately, in this case one should observe scattering in the lines $\lambda = 1066.7$ Å, $\lambda = 1048.2$ Å excited by the continuous solar spectrum which is very weak in this region. However, such observations are very interesting for Mars and Venus, since argon remains in an atmosphere during the whole time of evolution of the planet and its atmosphere. A study of its abundance in the atmospheres of planets is important for a construction of cosmogonical theories.

Note added in proof. The observations, which were obtained in Ly-α line from OGO-5 by French and American groups, give one maximum and one minimum at the sky. The maximum of brightness has an annual parallax, corresponding to a distance from the Sun about 5AU. These observations confirm a model of moving of the Sun in direction $\alpha = 15^h$, $\delta = -22°$. Two models are possible: a 'cold' model with densities of neutral atoms ~ 0.05 cm^{-3} and $T \sim 300$ K, and a 'hot' model which gives densities ~ 0.1 cm^{-3} and $T \sim 10^3$–10^4 K. (Bertaux, J. L. and Blamont, J. E., 1971, *Astron. Astrophys.* **11**, 200; Thomas, G. E. and Krassa, R. F., 1971, *Astron. Astrophys.* **11**, 218.)

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