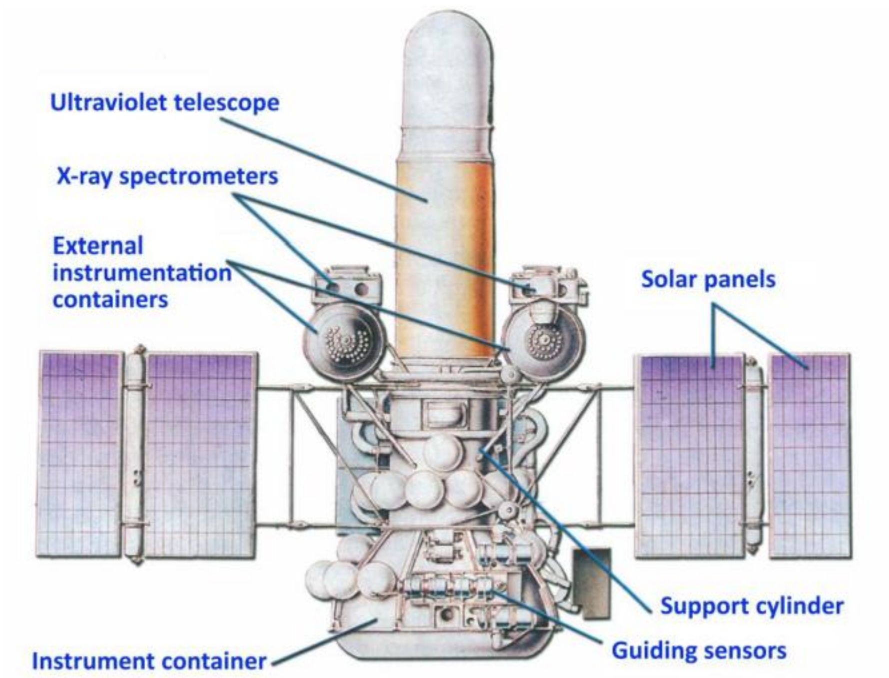
History: SN1987A and the UV Astron mission.

I.S. Savanov (INASAN, Moscow)

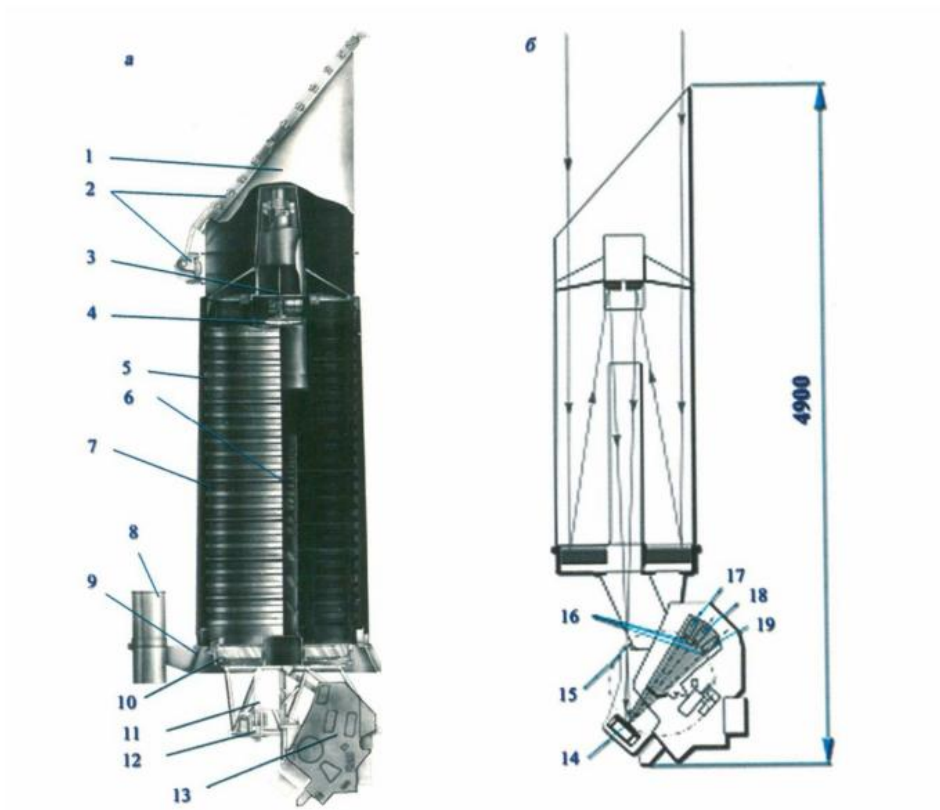
The Astron orbital station was designed for astrophysical observations and was launched by Proton launch system on 23 March 1983. Astron had a 80cm ultraviolet telescope with a mass of 400kg and a complex of X-ray spectrometers with a mass of 300kg on board as a payload. Among the most important observations by Astron were those of SN 1987A. In future the World Space Observatory — Ultraviolet mission, planned for launch in 2021 will be able to become an essential tool of UV research in the following decade.

THE SOVIET ASTRON ORBITAL STATION WAS DESIGNED FOR THE ASTROPHYSICAL OBSERVATIONS.

IT WAS LAUNCHED BY PROTON SYSTEM ON 23 MARCH 1983. ASTRON HAD A 80CM ULTRAVIOLET TELESCOPE WITH MASS OF 400KG AND A COMPLEX OF X-RAY SPECTROMETERS WITH MASS OF 300KG ON BOARD AS A PAYLOAD.



Astron was based on the Venera spacecraft and designed jointly by Lavochkin Research and Production Association together with Crimean Astrophysical Observatory and Marseille, MATRA laboratory (France).



IT WAS OPERATIONAL FOR SIX YEARS AS THE LARGEST ULTRAVIOLET SPACE TELESCOPE DURING ITS LIFETIME.

It's high apogee orbit (with apogee ~200,000 km and perigee ~ 2,000 km) permitted to exclude the influences of the Earth's umbra and radiation belts from the measurements.

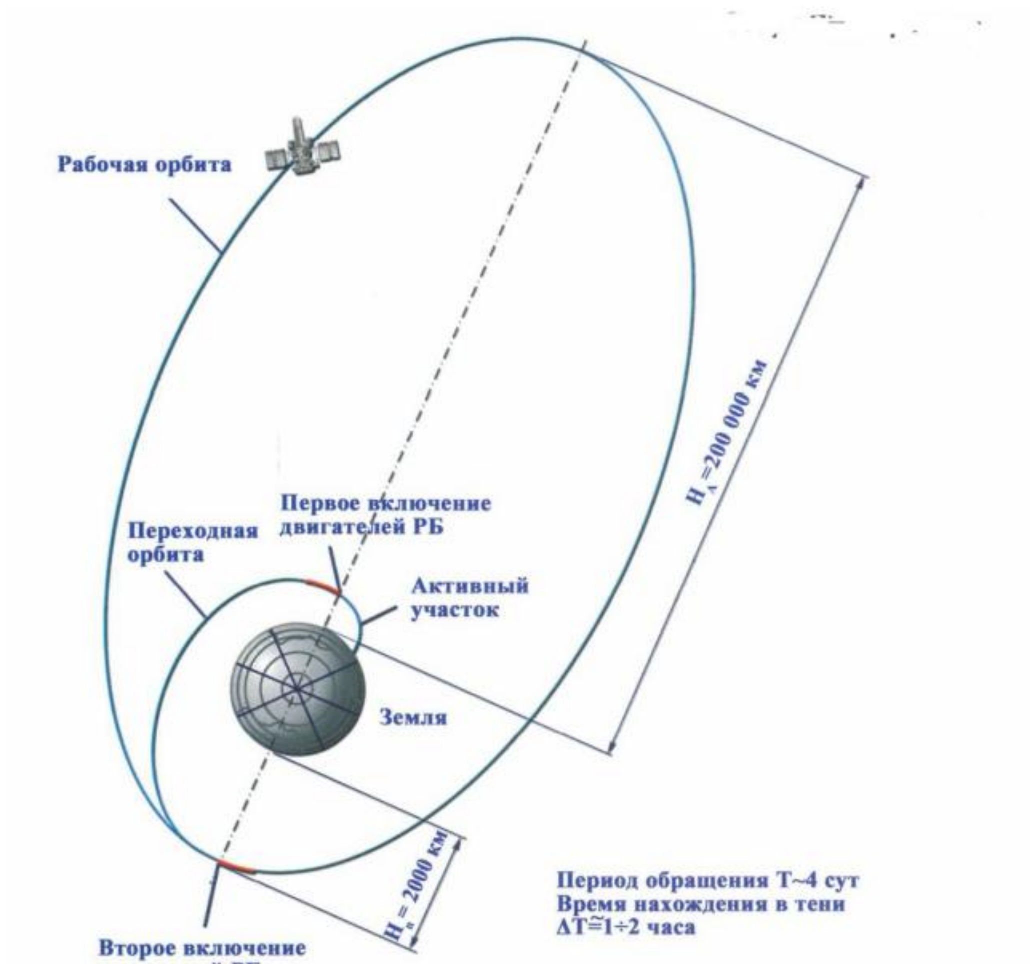
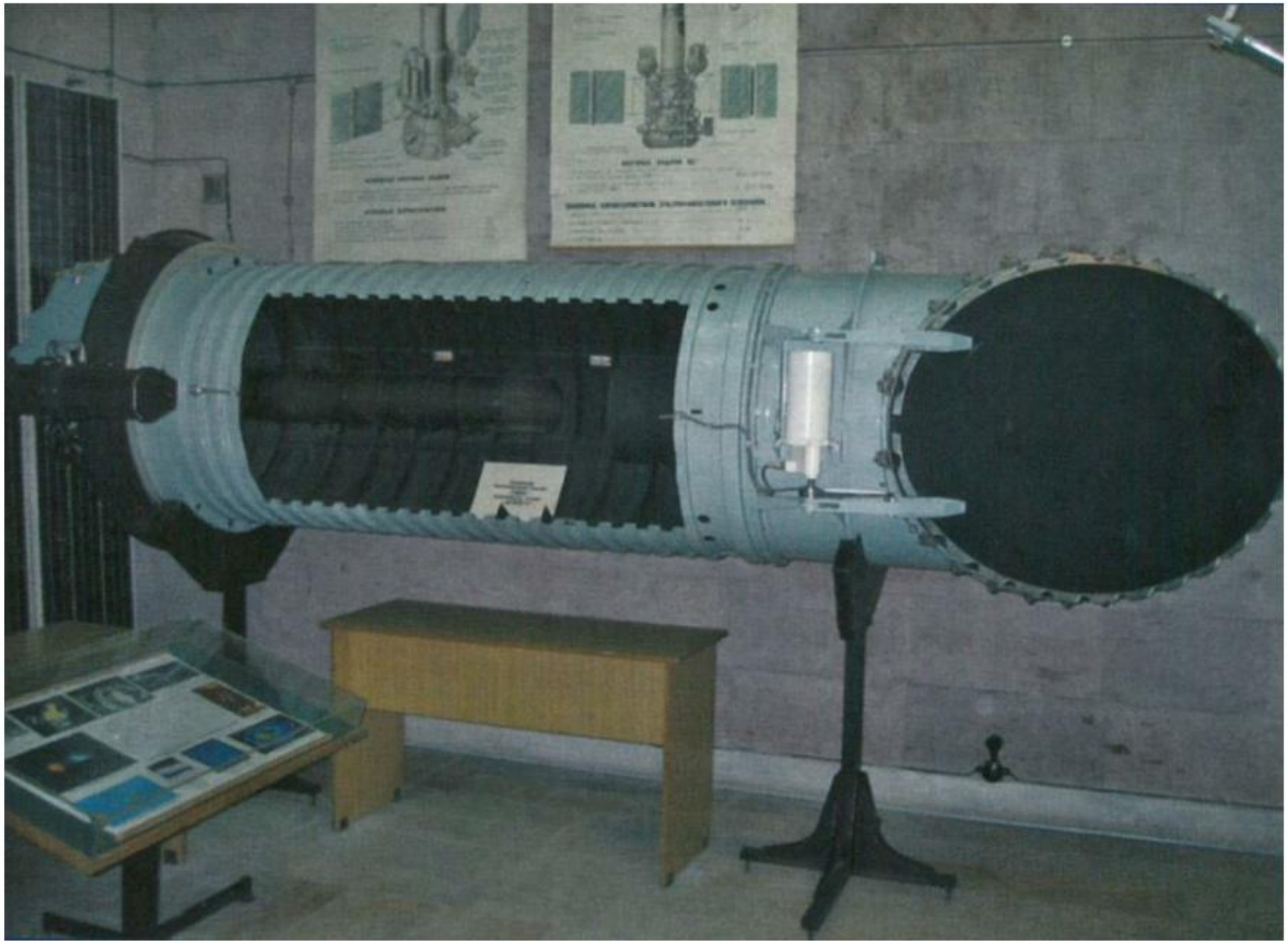
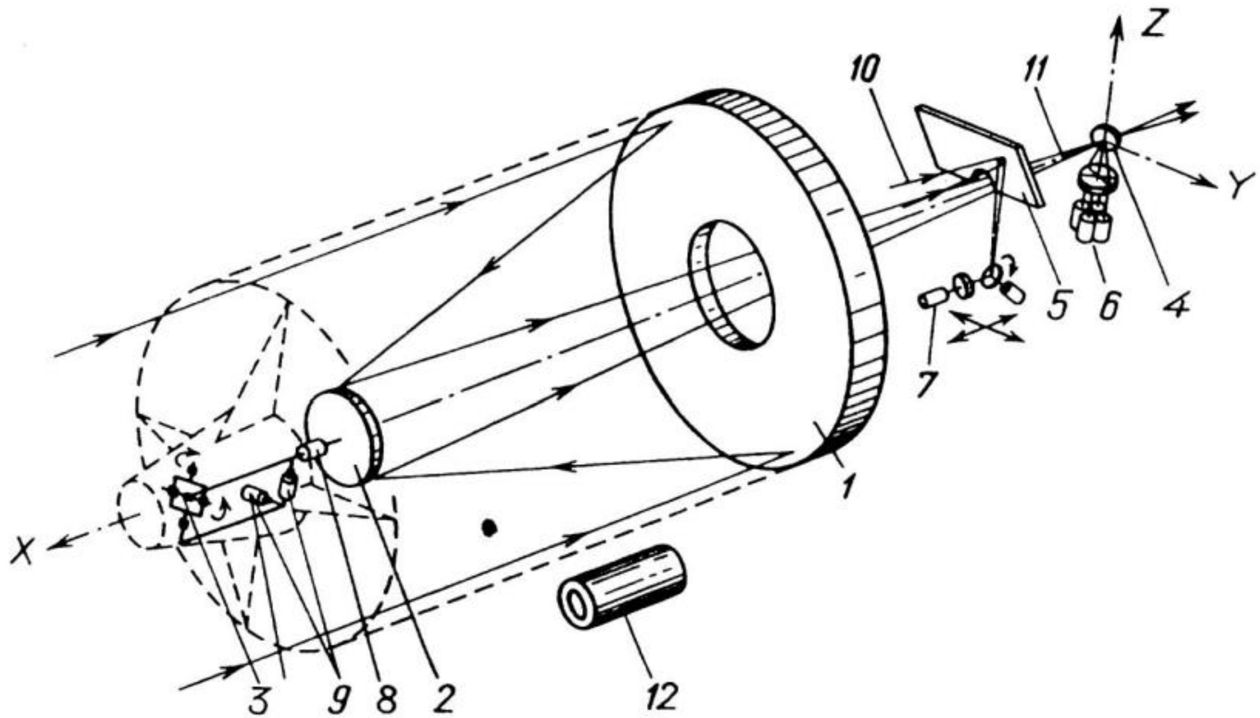


Рис. 3.1. Схема полета КА «Астрон»



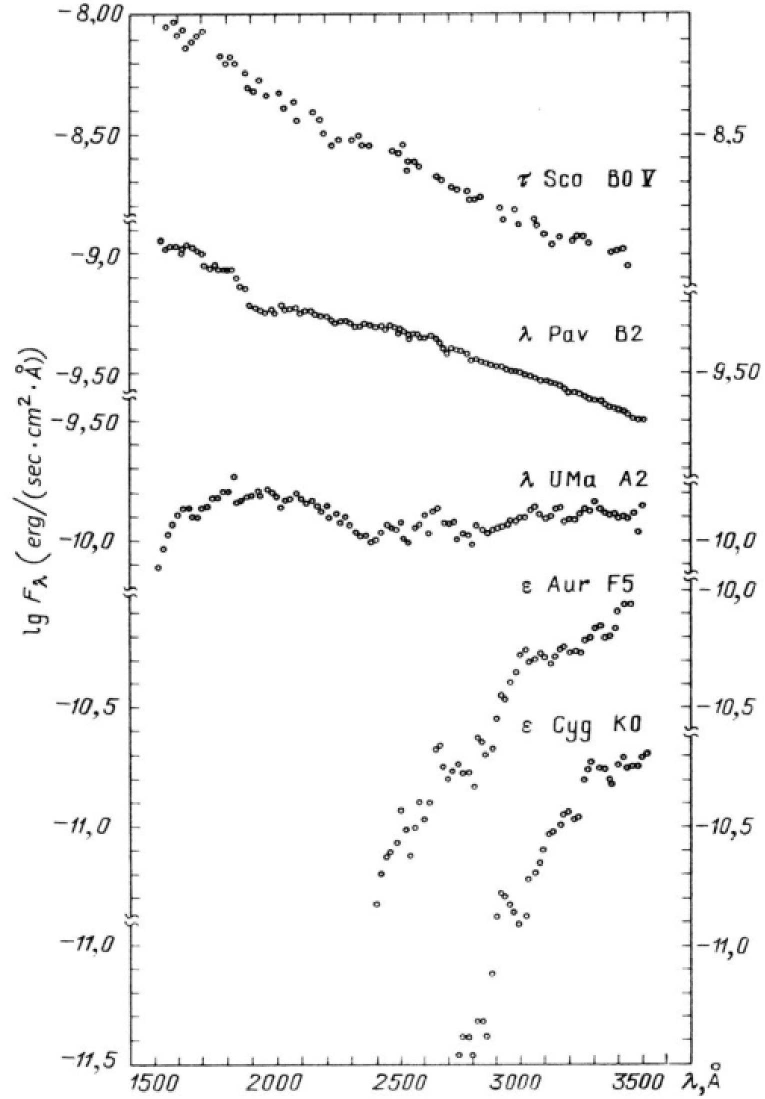

Z
10
11
Y
5
6
4
7
1
X
3
9
8
2
12

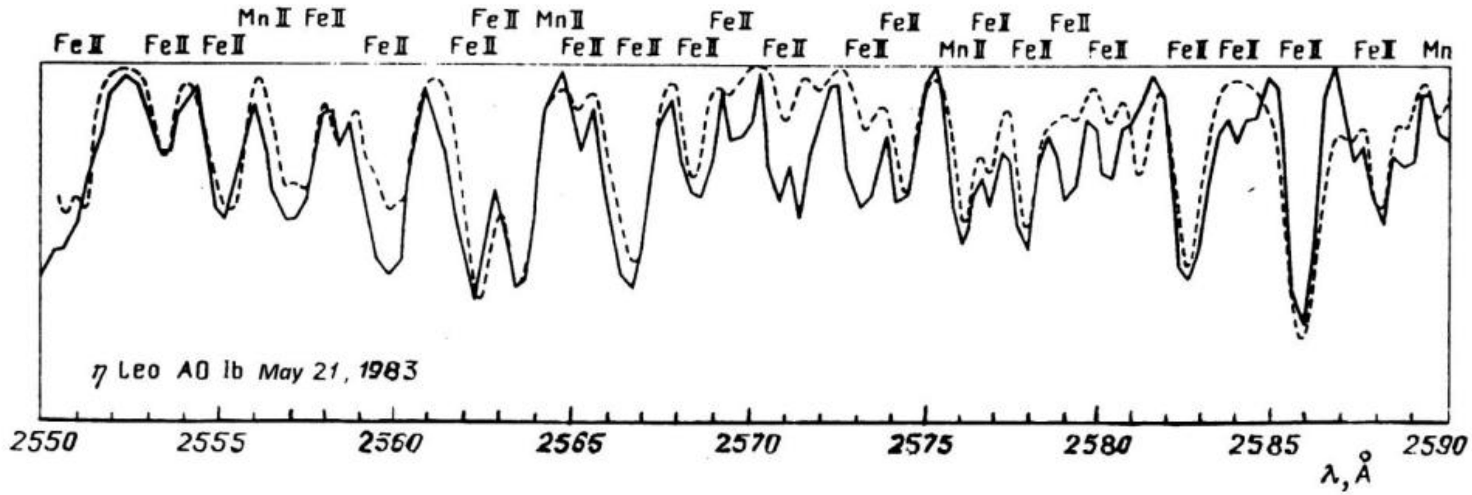
SPECTRAL OBSERVATIONS WERE OBTAINED FOR MORE THEN A HUNDRED STARS OF VARIOUS TYPES, ABOUT 30 GALAXIES, TENS NEBULAS AND SEVERAL COMETS.

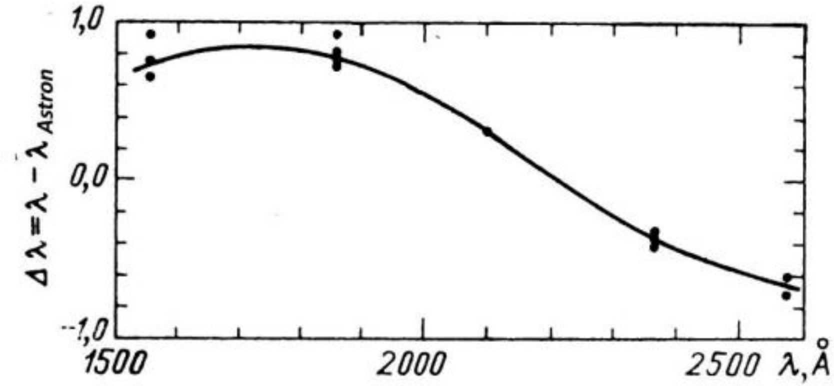
159 SET OF OBSERVATIONS FOR 105 STARS

CP STARS

O STARS WITH DIFFERENT EXTINCTION




Fe II
Fe II Fe II
Mn II Fe II
Fe II
Fe II
Fe II Mn II
Fe II Fe II Fe II
Fe II
Fe II
Fe II
Fe II
Mn II Fe II
Fe II
Fe II Fe II
Fe II
Fe II Fe II Fe II Fe II Mn
η Leo A0 Ib May 21, 1983
2550
2555
2560
2565
2570
2575
2580
2585
2590
λ, Å

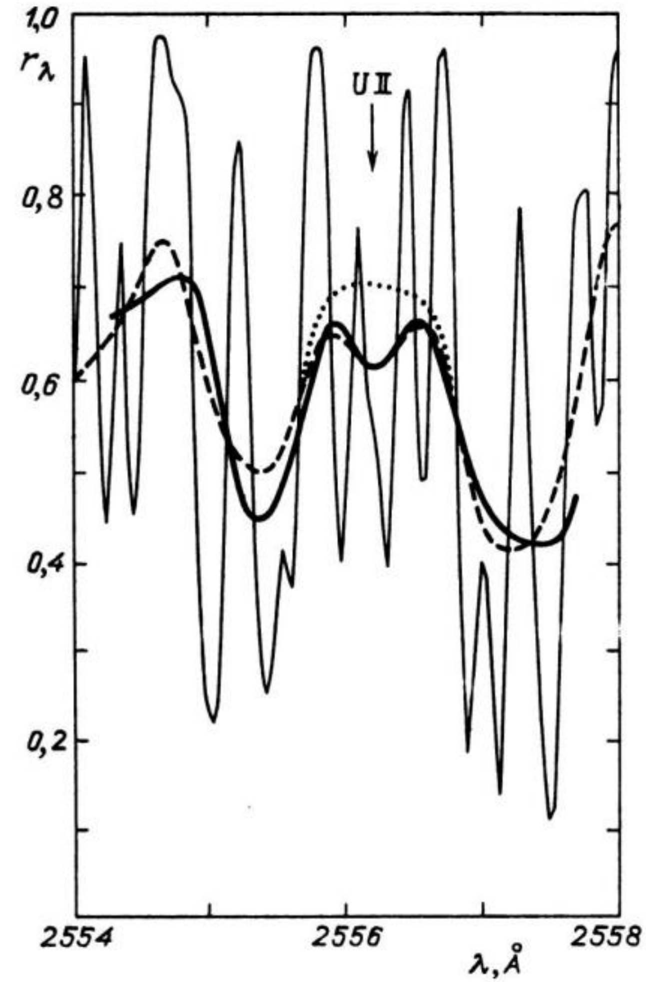

1,0
0,0
-1,0
Δλ = λ − λ Astron
1500
2000
2500 λ, Å

CP STARS

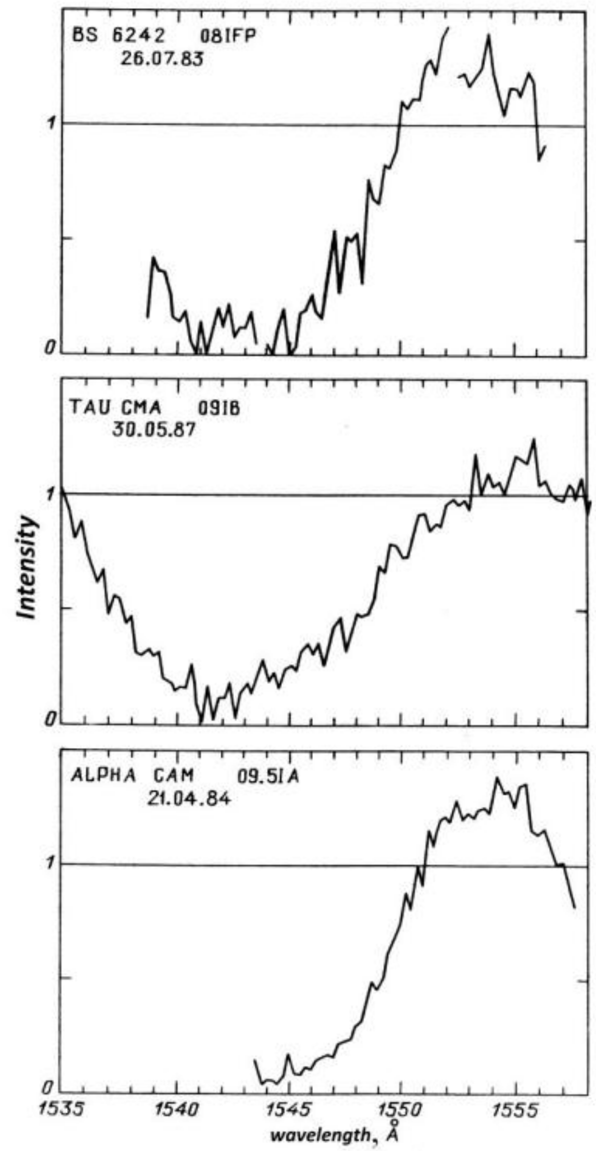
U II 2556.19 TH II 2368.05
PB II 2203.53 W II 2204.48

5 A SPECTRAL REGIONS

73 DRA
[U/H]=4.3
U II 3859.58



Mass loss – O stars

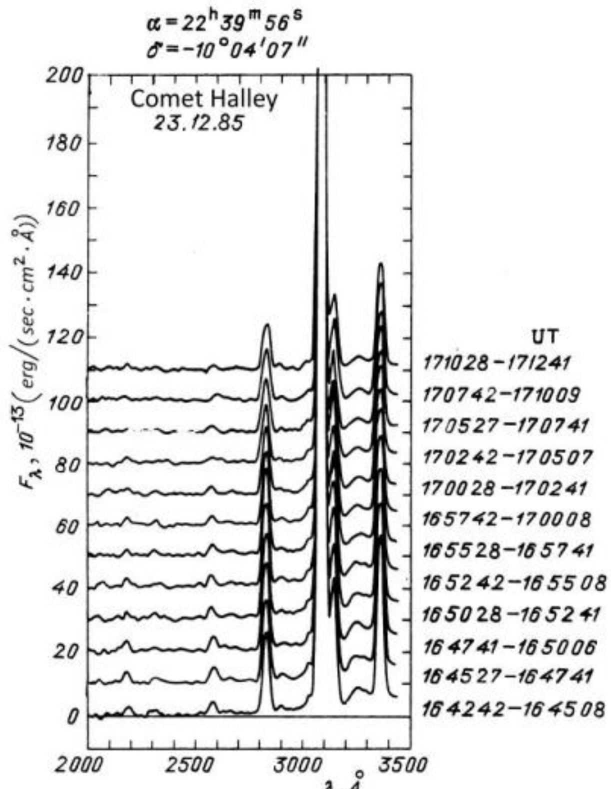


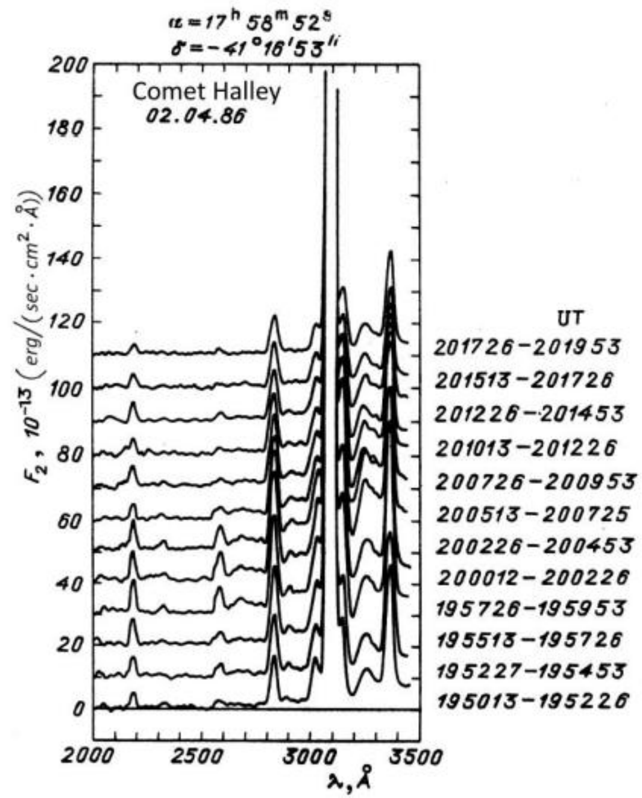
Observations by Astron of Halley's Comet in 1985 and 1986

+ 3 comets

Model of the coma surrounding Halley's Comet.

OH 309.0 nm





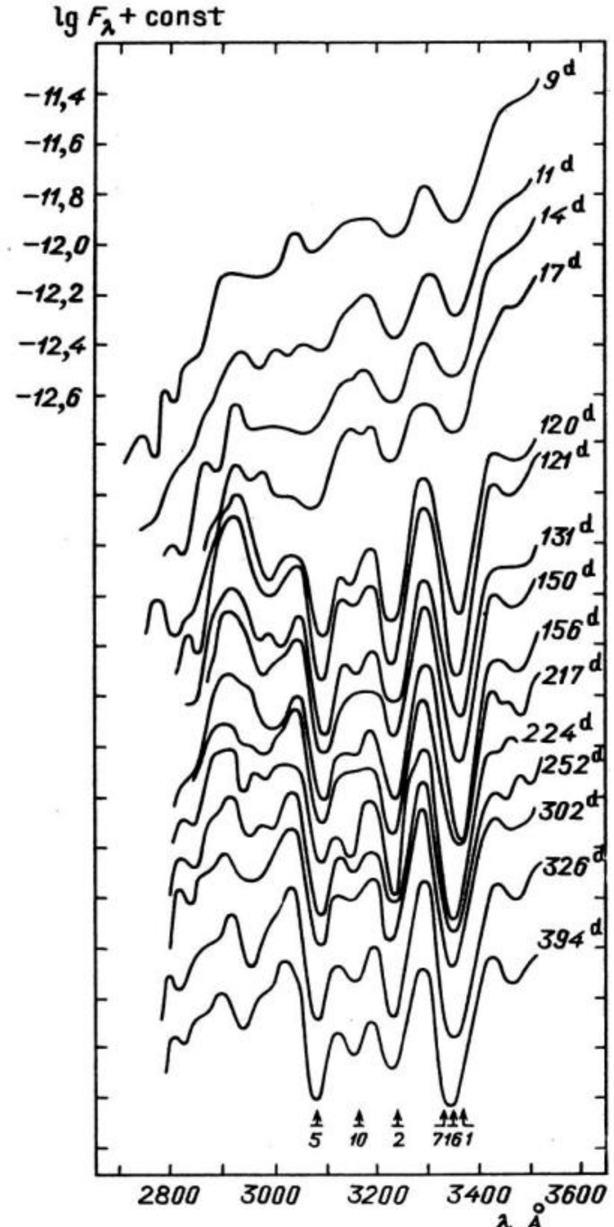
AMONG THE MOST IMPORTANT OBSERVATIONS BY ASTRON WERE THOSE OF THE SN 1987A .

15 SETS OF OBSERVTIONS

308.0 323.0 335.0 NM

RV= F(TIME)

TI II MULTIPLETS



Observations of supernova 1987A in the Large Magellanic Cloud from the Astron station

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A. V. Terebizh, Ch. T. Khua, and A. I. Sheikhet

Crimean Astrophysical Observatory, Academy of Sciences of the USSR, Nauchnyi
Laboratoire d'Astronomie Cosmique, Marseille, France

(Submitted May 19, 1987)
Pis'ma Astron. Zh. **13**, 739–743 (September 1987)

Tabulated results of observations of supernova 1987A are given. The observations were carried out from 4–12 March 1987 in the ultraviolet range, with the aid of the Astron astrophysical station.

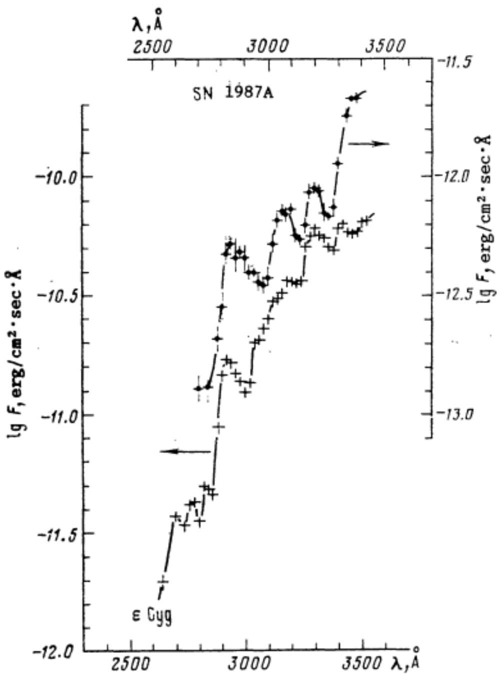


FIG. 1. Absolute energy distribution in spectrum of supernova 1987A on 12 March 1987 (upper and right-hand scales). Energy distribution in spectrum of normal K giant ε Cyg is shown for comparison (lower and left-hand scales). Length of vertical line corresponds to amount of squared error.

Taking into account that the Large Magellanic Cloud is 52 kpc away, the distance to ε Cyg is 23 pc, and the radius of a K0 giant is 16 $R_\odot$ and also that on 12 March 1987 in the 3100 Å region ε Cyg was 50 times brighter than supernova 1987A (see Fig. 1), we find that the radius of the supernova photosphere at that time was equal to 24 AU, i.e., it was larger than the radius of the orbit of Uranus, while the mean rate of increase of the photosphere radius from the time of outburst was close to 2400 km/sec. The latter figure is appreciably lower than the rates of outflow, calculated according to the width and shift of the emission lines, usually observed during nova outbursts.

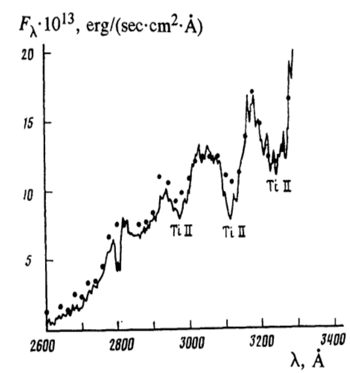


FIG. 1. Ultraviolet spectra of SN 1987A in the vicinity of strong Ti II lines, obtained on 4 March 1987 by the *Astron* station (points) and the IUE satellite (solid curve).

Supernova 1987A: analysis of ultraviolet absorption spectra obtained by the Astron station

L. S. Lyubimkov

Crimean Astrophysical Observatory, USSR Academy of Sciences

(Submitted July 21, 1989)

Astron. Zh. **67**, 480–493 (May–June 1990)

Absorption spectra of Sn 1987A in the near ultraviolet, obtained by the Astron Station between the 9th and 394th day after the explosion, are investigated. The radial velocity V_r is measured from the shift of the λ 3230 Å blend; its dependence on time t is well approximated by a power law, $V_r \propto t^{-1/3}$. It is shown that the ionization of Fe I atoms, and possibly of other elements in the iron group in the supernova shell, is considerably higher than the equilibrium value, which greatly weakens the lines of neutral atoms. Calculations of synthetic spectra suggest that the absorption blends at 3350, 3230, and 3080 Å, the clearest features in the investigated part of the spectrum, are formed by lines of the first Ti II multiplets. Abrupt strengthening of the blends at $t \geq 120$ days is noted in comparison with spectra obtained at $t = 9$–17 days; one possible explanation is that titanium synthesized in the supernova explosion was observed in the shell starting at $t = 120$ days.

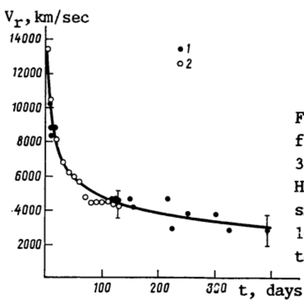


FIG. 3. Radial velocity as a function of time based on the λ 3230 Å blend (1) and the Hα, Hβ, and Hγ lines (2). The smoothed curve, obtained by the least squares method, corresponds to a power law $V_r \propto t^{-1/3}$.

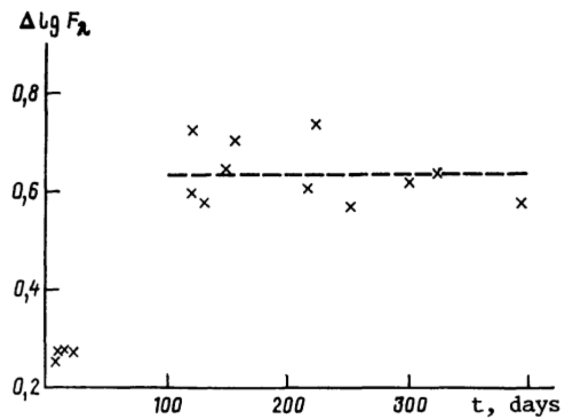


FIG. 5. Evolution of the depth of the 3350 Å blend. The dashed line corresponds to the mean value at $t \geq 120$ days.

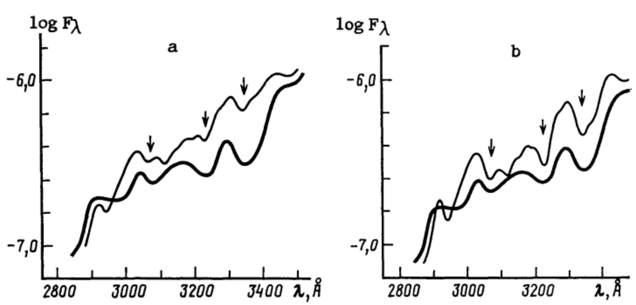


FIG. 6. Comparison of the observed spectrum of the supernova obtained on 4 March 1987 (heavy curves) with synthetic spectra (thin curves) calculated from lines of ions with standard (a) and enhanced (b) metal abundance. The blends formed almost entirely by Ti II lines are indicated by arrows in the synthetic spectra.

Strong absorption lines in the spectrum of supernova 1987A in the first months after the explosion: variations of lines of heavy elements

L. S. Lyubimkov

Crimean Astrophysical Observatory, USSR Academy of Sciences

(Submitted August 7, 1990)

Astron. Zh. **68**, 1261–1273 (November–December 1991)

Variations in the equivalent widths W_λ and depths d_λ of Ti II, Fe II, Ba II, and Na I absorption lines during the first months after the explosion of SN 1987A are analyzed. It is shown that the decrease in shell temperature was probably succeeded by an increase at a certain stage, resulting in an abrupt change in the behavior of the $W_\lambda(t)$ and $d_\lambda(t)$ curves. Rough estimates show that the observed weakening of the BA II 6142 Å line and the approximate constancy of the FE II 5169 Å over the interval $t = 25$–120 days can be explained by a 1500 K increase in temperature; the simultaneous strengthening of UV Ti II lines requires a tenfold increase in Ti abundance for its explanation. The warming propagated in the shell with velocity $v \approx 8000$ km/sec and began at the photosphere level in the period $t = 10$–20 days. It is shown that the anomalies in the behavior of radial velocities measured from Balmer lines appeared in the same period and with the same velocities.

Strong absorption lines in the spectrum of supernova 1987A in the first months after the explosion: variations of Balmer lines

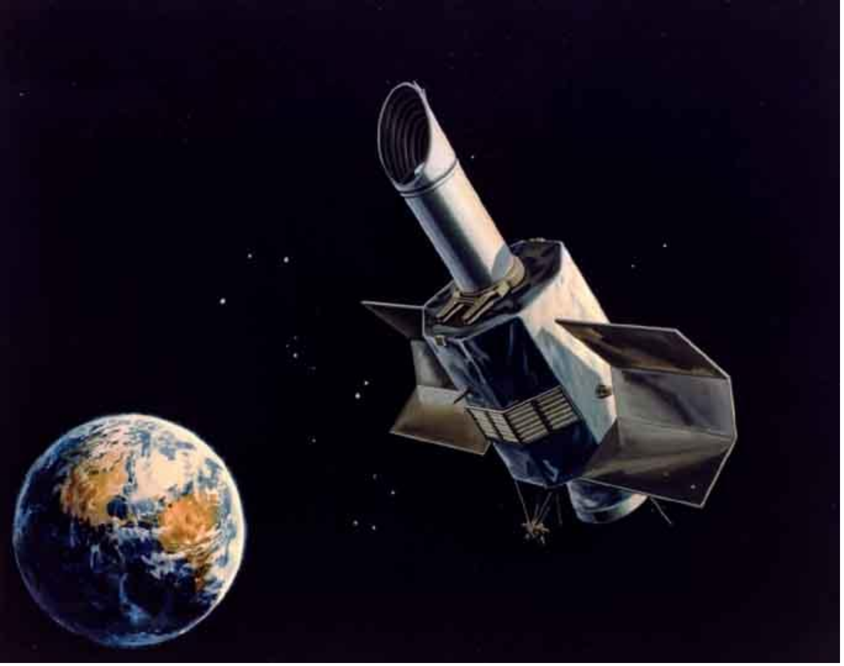
L. S. Lyubimkov

Crimean Astrophysical Observatory, USSR Academy of Sciences

(Submitted August 7, 1990)

Astron. Zh. **68**, 969–983 (September–October 1991)

Variations in the equivalent width W_λ and radial velocity v of Balmer lines in the spectrum of SN 1987A during the first months after the explosion are analyzed. The shape of the $W_\lambda(t)$ curves for the Hα and Hβ absorption lines in the period $t \lesssim 120$ days, including the presence of two maxima, is explained by temperature variation in the regions of production of those lines: its rapid drop at $t < 40$–50 days and its subsequent rise by $\Delta T \approx 500$ K. It is shown that in the time between the first and second Hα and Hβ maxima, the density in these regions decreased by more than an order of magnitude, and this may be why the second maximum was considerably lower than the first. Anomalies in the velocity dependence $v(t)$ measured from Hα-Hδ lines are discussed; periods of constancy of $v(t)$ in those lines and in some Fe II and Ba II lines are found.



The SuperNova/Acceleration Probe (SNAP)

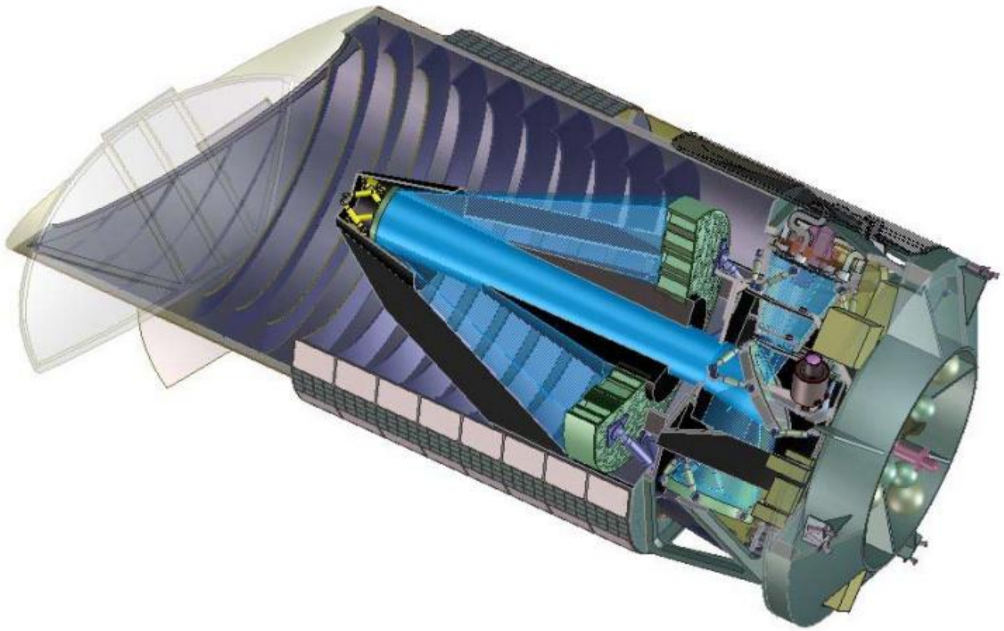


Fig. 2: Cutaway view of SNAP. The entire telescope telescope attaches to the spacecraft structure at right by means of bipods. The outer baffle, shown cut away, also attaches to the spacecraft structure by means of its separate supporting struts. A hinged split door, shown open in light gray, protects the cleanliness of the optics until on-orbit commissioning begins. Solar panels are fixed, not deployed.

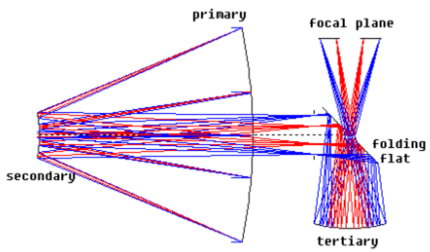
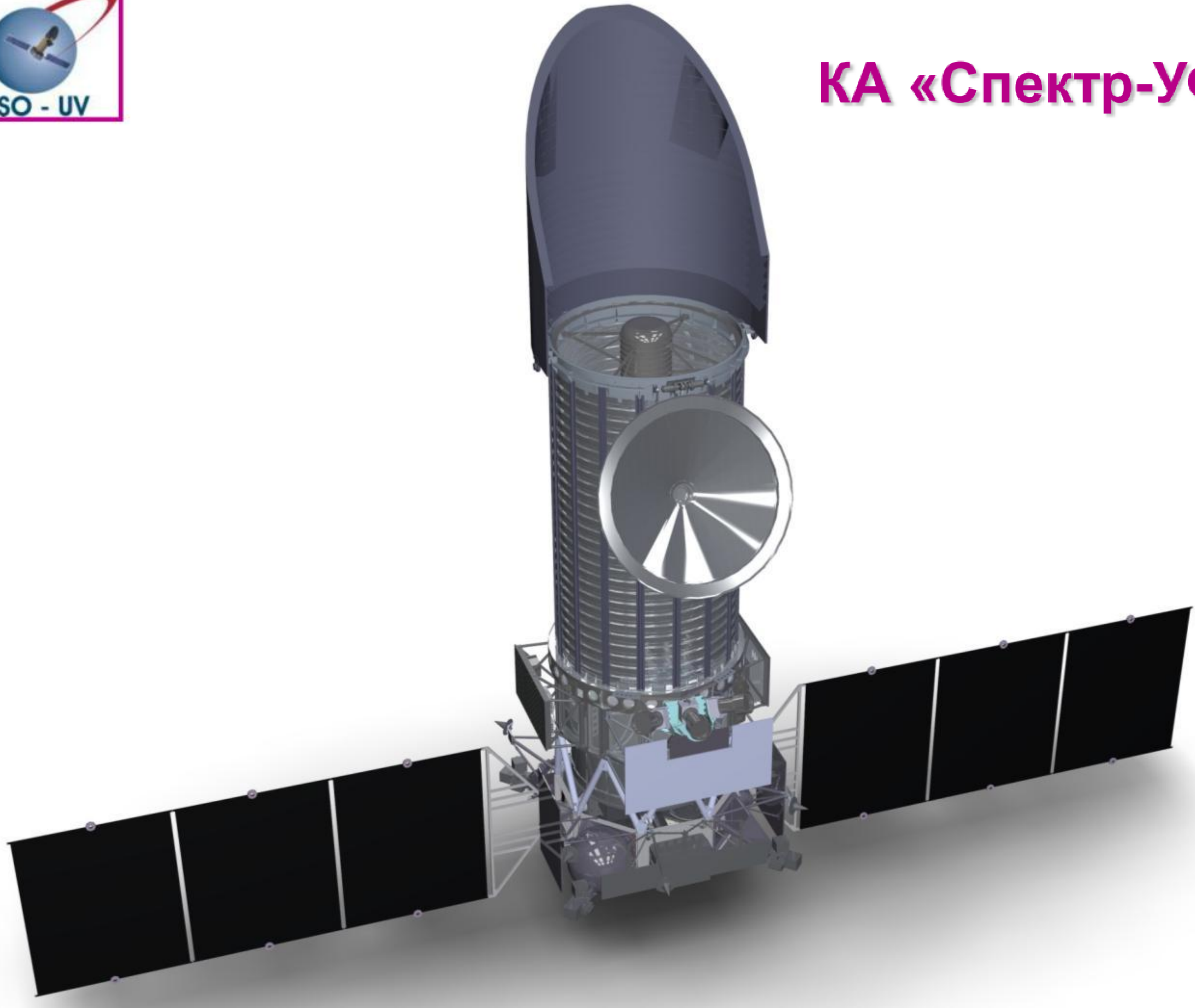


Fig. 1: SNAP optics layout. The entrance pupil is defined by the primary mirror. A field stop is located behind the primary mirror (vertical marks) for stray light control. The exit pupil is at the folding mirror.

Table 1: Optical Surfaces and Locations

	Diameter, meters	Central hole, meters	Curvature, recip meters	Asphericity	Xlocation, meters	Zlocation, meters
Primary	2.00	0.5	-0.2037466	-0.981128	0	0
Secondary	0.45	none	-0.9099607	-1.847493	0	-2.00
Folding flat	0.66 x 0.45	0.19 x 0.12	0	0	0	+0.91
Tertiary	0.68	none	-0.7112388	-0.599000	-0.87	+0.91
Focal plane	0.567	0.258	0	0	+0.9	+0.91

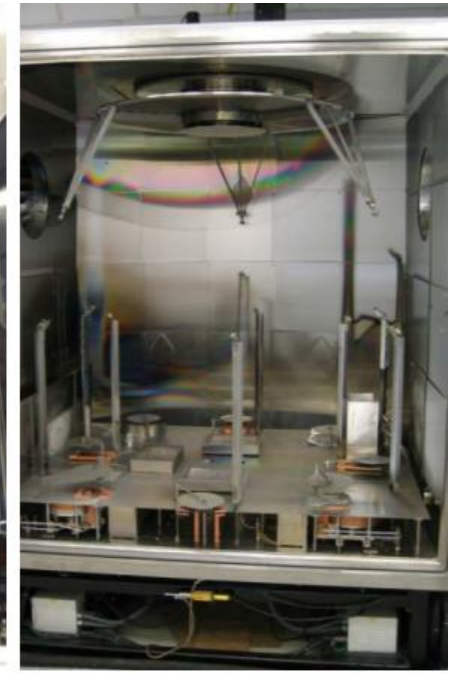
КА «Спектр-УФ»



- Изготовлены МО ГЗП, МО ВЗП
- Отработана технология нанесения штатного покрытия $AlMgF_2$

- Проводятся КДИ МО ГЗП, МО ВЗП, окончание 11.2015

- ШО ГЗП, ШО ВЗП в стадии изготовления, окончание 11.2015

МО ГЗП и ВЗП после напыления штатного покрытия, 2013г.


МО ГЗП, транспортный контейнер

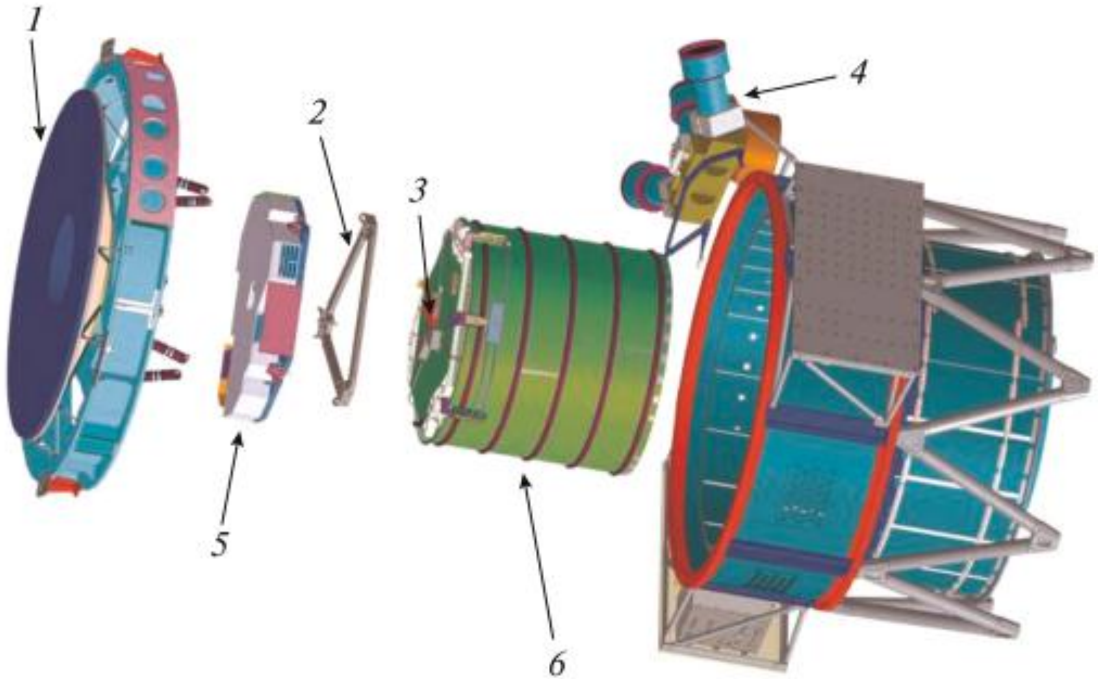
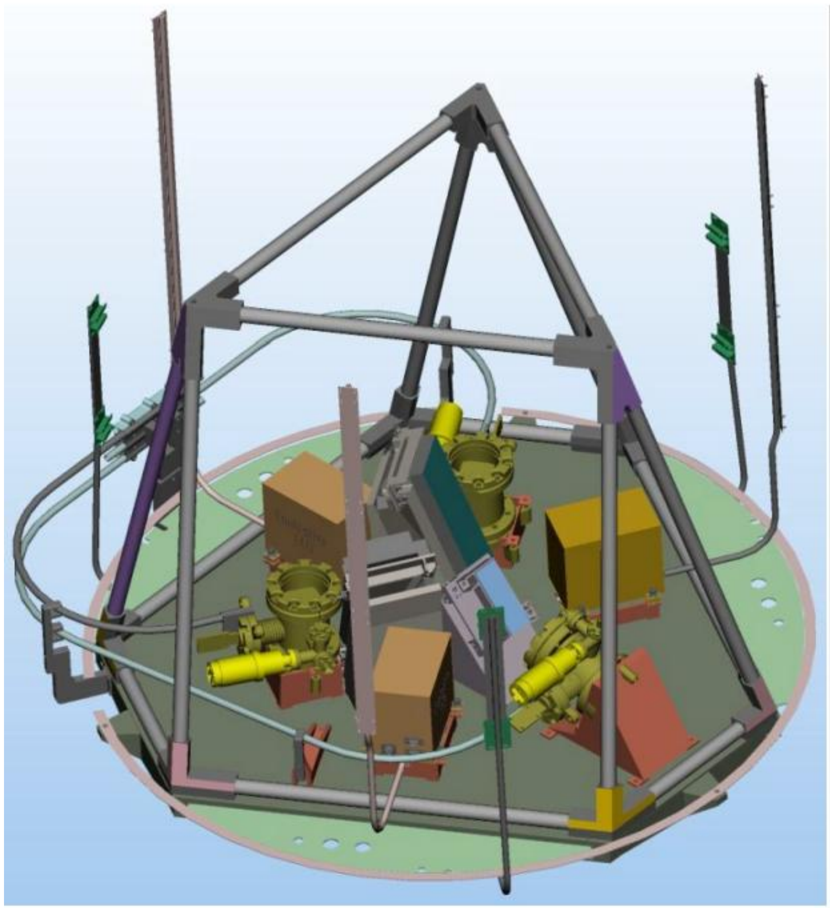


Fig. 3. Instrumentation compartment of the T-170M telescope of the *WSO-UV* mission: (*1*) primary mirror; (*2*) optical bench; (*3*) guidance sensor system of the spectrograph unit; (*4*) star trackers; (*5*) field cameras unit; (*6*) spectrographs unit.



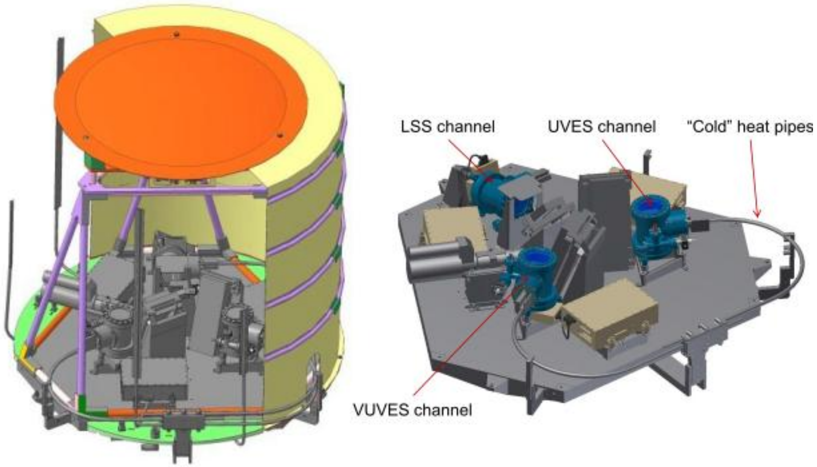


Fig. 1. WUVS optical-mechanical unit layout (left), detector subsystem location on WUVS optical bench (right).

Table 1. Main characteristics of WUVS detectors.

Characteristics	**VUVES**	**UVES**	**LSS**
Spectral range, nm	115-176	174-310	115-305
CCD AR coating	Uncoated	Uncoated 174-200 Gradient 200-310	Uncoated 174-200 Gradient 200-305
Readout amplifiers	Top, Bottom	Top, Bottom	Left, Right
Size of photosensitive area, mm	37.3 x 49.1		
Pixel format	4096 x 3112		
Pixel size, µm	12		
Readout speeds, kHz	50, 100, 500		
Readout noise at 50/100 kHz, e^-	3/4		
Saturation signal, e^-	30000		
Digitalization, bits	14		
Dark current, e^-/pixel/h at the beginning of life at the end of life	 3 9		
CCD temperature, °C	-100		
Enclosure foot temperature, °C	+20		
Thermal load at Cold finger, W	3		
Typical exposure time, s	600		
Data interface	SpaceWire 25 Mbits/s		
Power, V	27		
Power consumption, W	10.5		
Mass, kg	9.1		

Fig. 7. CCD enclosure EM and CEB EM delivered to LPI.

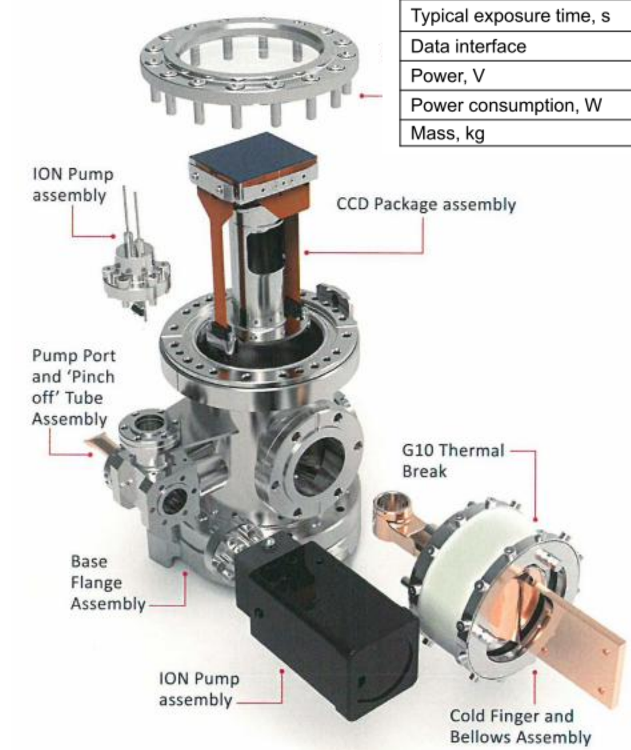
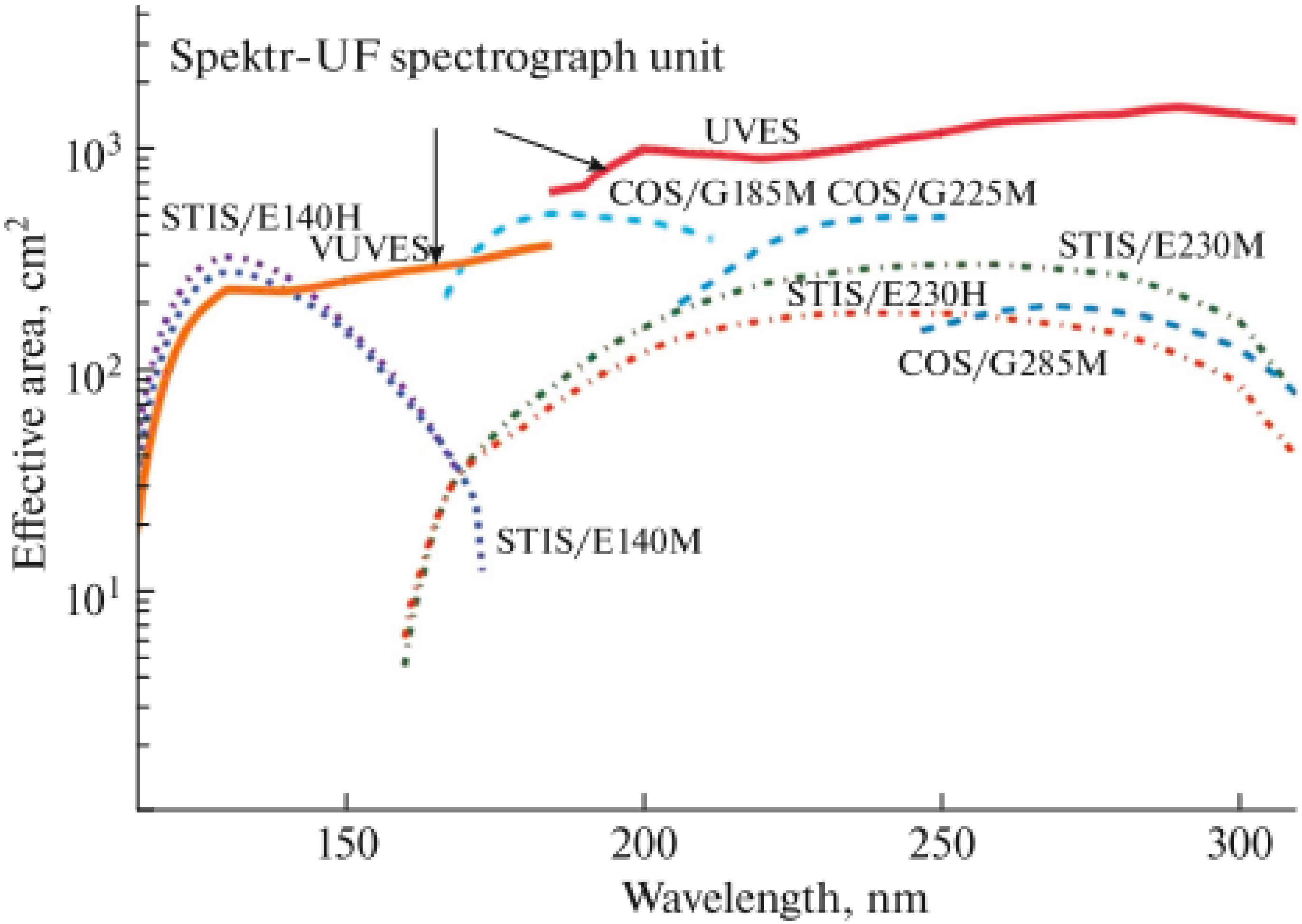


Fig. 4. CCD Enclosure composition.



Spektr-UF spectrograph unit
UVES
COS/G185M COS/G225M
STIS/E140H
VUVES
STIS/E230M
STIS/E230H
COS/G285M
STIS/E140M
10^3
10^2
10^1
Effective area, cm^2
150
200
250
300
Wavelength, nm

• НГММТЭ ISSIS поставлен в НПОЛ – 2013
• Проведены ТВИ сборки ППВР-2 – 2013
• ТВИ ИО – лето 2014г.

• Контракт с SENER на изготовление ТО ISSIS **не подписан**.

• Имитатор ТО ISSIS для стыковочных испытаний ТО КОНП изготовляется в ИКИ РАН по исх. данным UCM – лето 2014г.

НГММТЭ ISSIS

Спасибо за внимание!