OBSERVATIONS OF STABLE AURORAL RED ARCS (SAR-ARCS) IN YAKUTIA

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In 1987-1990 at station near Yakutsk (L ~ 3.2) the photometric and photographic observations of subvisual stable mid-latitudinal red arcs have been carried out. Registration was carried out simultaneously by a scanning photometer and by an all-sky monochromatic chamber and it followed to reveal unambiguously the SAR-arcs with intensified emission only 630.0 nm [OI]. SAR-arcs are located to the equator of diffusion auroral zone of outer plasmasphere. During periods with elevated geomagnetic activity the arcs appear a lower geomagnetic latitudes out of dependence of local time and move to the equator with elevated velocity of drift.

Introduction

Subvisual arcs in 630.0 nm emission [OI] at mid-latitudes were first observed by Barbier in 1956 from Haute Provence [1,2]. That mid-latitudinal arched airglow with the enhanced brightness of 630.0 nm emission was called a stable auroral red arc, i.e. SAR-arc [2]. SAR-arcs are one of the unique physical phenomena in subauroral upper atmosphere and since their discovery the SAR arcs attract researcher's attention. But the SAR-arcs registration presented some difficulties. Numerous reviews (for example 3,4) describe SAR-arc phenomenon morphology and its dynamics in the process of world magnetic storm development according the SAR-arc observation results.

SAR-arcs represent processes in the magnetosphere region (plasmasphere, plasmapause, ring current) which are projected by the magnetic field line on subauroral latitudes of the Earth so the SAR-arcs being the ionosphere phenomenon have the magnetospheric origin and belong to the problem of interaction of magnetosphere with ionosphere.

There was not the trustworthy information on the SAR-arc observation on the European-Asian continent till present time.

In this paper the results of the first photometric and photographic SAR-arc observations in Yakutia are presented.

Photometric and photographic measurements.

The optical measurements were carried out at st.Maimaga (Φ~63^o, Λ~129^o are geographic coordinates, Φ_c~56.5^o, Λ_c~200^o are geomagnetic ones). The mid-latitude red arc observations were started in November 1987 by two-channel scanning photometer with angle of vision 3 registering the airglow distribution in 630.0 nm and 557.7 nm emissions along the Yakutsk geographical meridian [5]. The analog record of signal with the amplitude resolution of 10-20 Rayleighs confidently allowed to register the airglow nonhomogeneities in a red line of the atomic oxygen which were typical for SAR-arcs with the amplitude 50 R. The upper limit of the registration interval 10 kR gave the opportunity to observe the diffuse auroral airglow poleward of the SAR-arc. The scanning from the southern horizon to the northern one was carried out for 40 s with the interval of 2 or 5 min.

The half-width of the interference light-filter is equal to 1-3.5 nm. The relative error of the photometer energetic graduation did nit exceed 30%.

The photometer red arc registration results have been compared with simultaneous observation data by all-sky monochromatic photocamera with the amplifier of the image brightness. The camera exposure time is 1 and 4 min. The example of photometric and photographic observations in 630.0 nm emission is shown in Fig.1. The photometric record displays the change of meridional distribution of 630.0 nm emission surface brightness in the course of time and separation of the SAR-arc from the diffuse auroral luminosity. The interval between scannograms is 20 min. The region of the arc luminosity is shown by vertical section lining. The intensification at large zenith angles is caused by the Van-Rhiyn effect. The separate time moment photographs of all-sky obtained in 630.0 nm emission using photocamera are given.

The observed SAR-arcs are basically stable, but can be changeable by brightness and width. The arc width can change from 400 to 150 km. The 630.0 nm emission intensity exceeds the atmosphere background emission level by a factor of 50-30 R but the intensity enhancement can be observed up to 1000 R and higher.

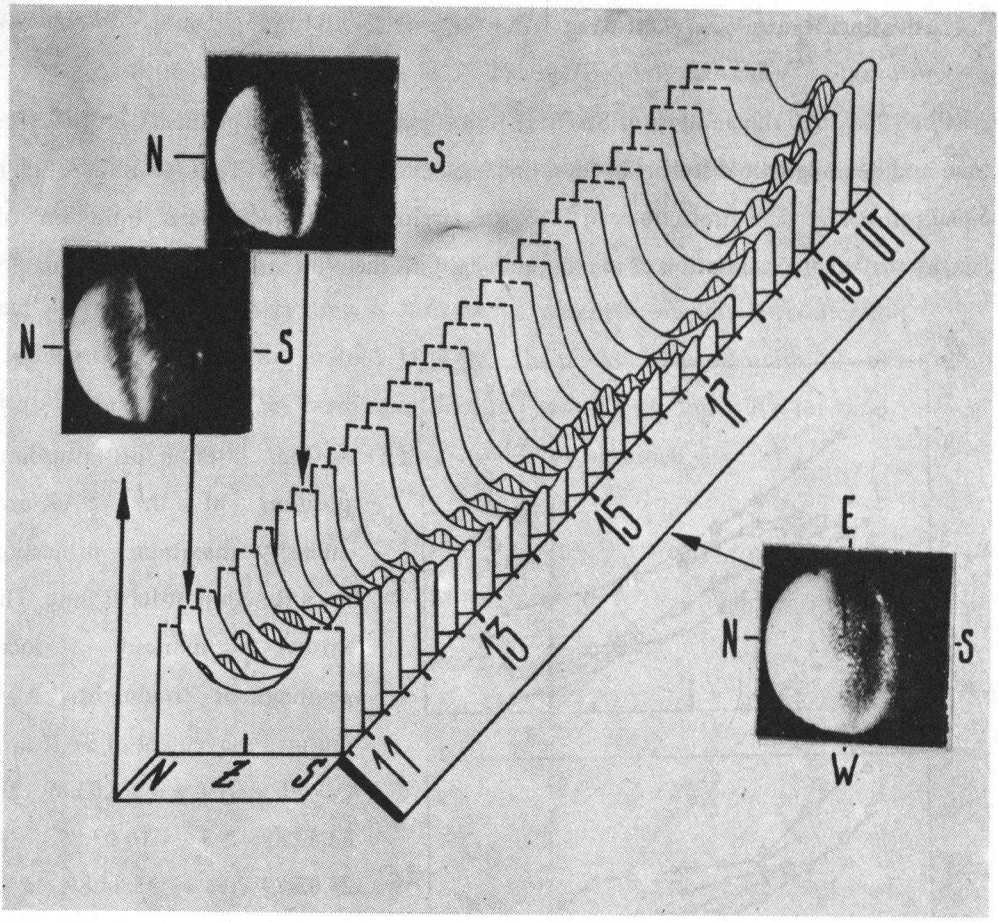

Fig. 1. Photometric and photographic registration of equatorial drift of SAR-arc for November 16, 1988. There are photometric records of distribution of upper atmosphere surface brightness radiation in the line 630.0 nm along the meridian (meridional photometric sectional view-scanograms) from northern horizon (N) to southern one (S) during the night of observation. The monochromatic photographs of all-sky have been also shown.

In the most cases SAR-arcs during evening twilight appear in the north or, rarely, near the observational station zenith and move equatorward in such way that to the start of morning twilight they are observed in the south horizon.

Latitudinal Dynamics of SAR-Arcs.

For 1988-1990 the analysis of SAR-arc latitudinal dynamics dependence on the local time and geomagnetic disturbance level has been carried out [6]. From scannograms in 630.0 nm the vertical projections of SAR-arc airglow region have been built on the Earth's surface in assumption of maximum height of their intensity at the 450 km .

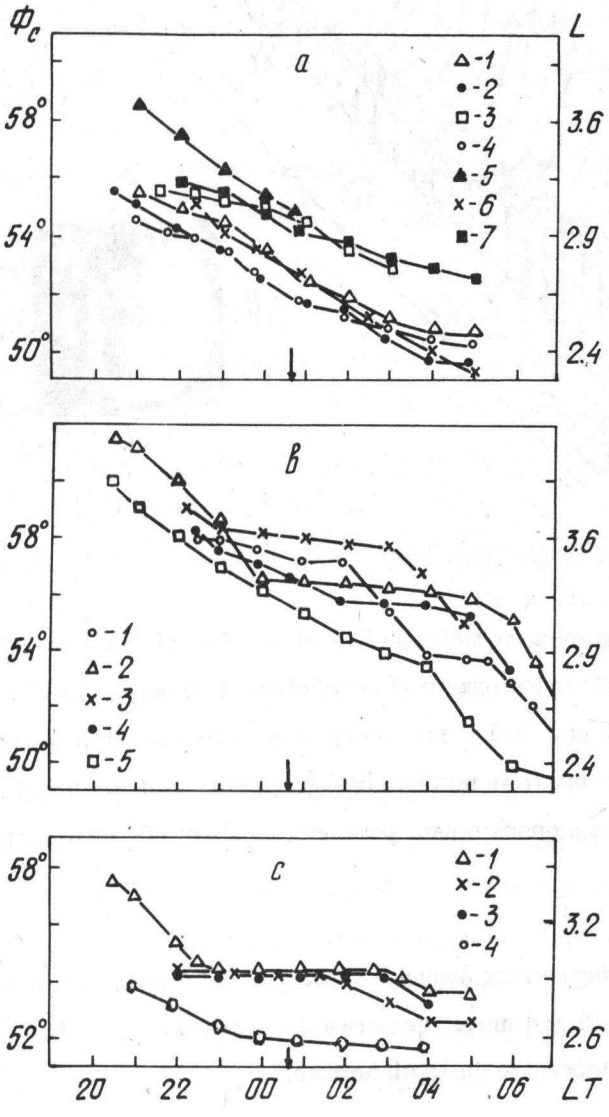

Fig. 2. Plots of latitudinal position of the SAR-arcs intensity maximum projection as a function of local time. The arrow marked local geomagnetic midnight: a - uniform movement of SAR-arcs (V~20 m/s) (1 - 02.03.89, 2 - 03.03.89, 3- 10.03.89, 4- 29.03.89, 5 - 01.04.89, 6 - 02.04.89, 7 - 04.04.89); b - nonuniform movement of SAR-arcs (v>40 m/s) (1 - 16.11.88, 2 - 09.01.89, 3 - 12.01.89, 4 - 04.02.89, 5 - 05.02.89); c - events of SAR-arc quasi-stationary location during ~ 6 h. (1 - 05.03.89, 2 - 09.03.89, 3 - 30.03.89, 4 - 05.04.89).

Different dependencies of latitudinal position of the red arc intensity maximum projection on the local time are given in Fig.2. A series of 16 observation nights is

divided in to three types of latitudinal SAR-arc dynamics: 1) SAR-arcs can move almost uniformly to the equator at the rate of 10-20 m/s (Fig.2a); 2) Against a background of such movement the irregular velocity enhancement up to 40-100 m/s (Fig. 2b) can occur that is connected with the intensification of magnetic and auroral activity; 3) It has been also registered the events of practically motionless SAR-arc (Fig. 2c), whose location is not changeable during 6-7 hours. The arc shift equatorward in Fig. 2c at the beginning and at the end of observation is because of magnetic activity intensification.

For observation period in 1989-1990 the correlation dependencies of observation latitude and velocity of SAR-arc equatorial movement from index Kp for time intervals 9-12, 12-15, 15-18 and 18-21 UT have been also obtained.

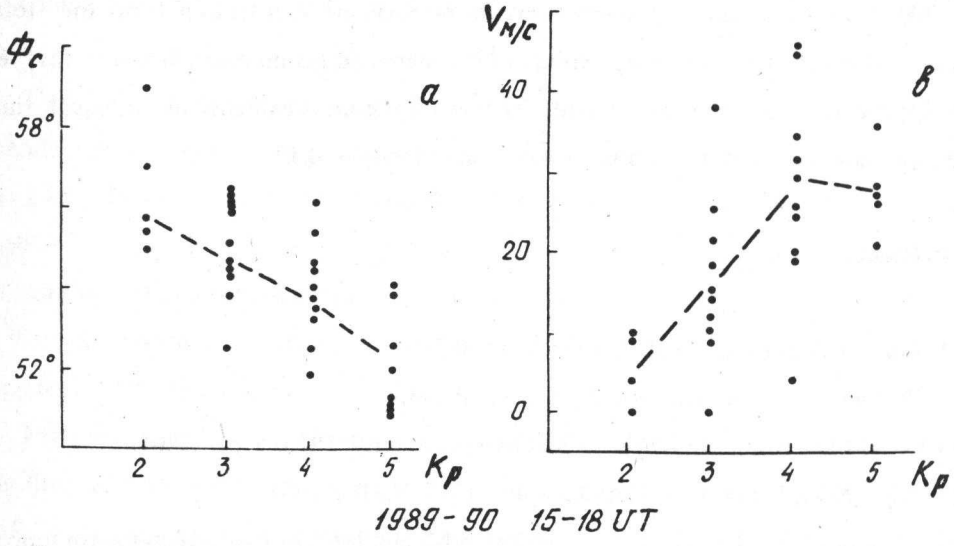

Fig. 3. Plots of spatial position of the SAR-arcs intensity maximum projection (a) and the mean velocity of SAR-arc equatorial movement (b) as a function of index Kp.

Fig.3 presents such dependence upon the current value Kp for the most statistically well provided post-midnight interval 15-18 UT (00.40-03.40 MLT). It is seen that the SAR-arc registration latitude decreases (Fig. 3a), and the mean velocity of their movement equatorward increases (Fig. 3b) as the planetary geomagnetic activity current index increases. Tendency for the decrease of equatorial movement velocity up to zero at low level of geomagnetic activity is also seen. Similar correlation dependence upon the current value Kp has been also obtained for other time intervals.

Conclusion

By first photometric and photographic SAR-arc measurements in the north-east of Yakutia are obtained following results:

The stable subauroral red arcs are localized equatorward of diffuse auroral luminosity, apparently, in the region of external plasmasphere projection. The registration of SAR-arcs of Yakutia confirms their presence in all longitudinal Earth's sectors.

The latitudinal SAR-arc dynamics dependence on the local time and the geomagnetic disturbance level has been revealed (on the basis of wide statistical data for 1988-1990, approximately 60-70% events of SAR-arc registration from the total number of observations). During periods of the increased geomagnetic activity the red arcs appear at lower geomagnetic latitudes beyond the independently on the local time and they shift equatorward with more increased velocity of drift.

References

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