THE 27-DAY VERSUS 13.5-DAY VARIATIONS IN THE SOLAR LYMAN-ALHPA RADIATION AND THE RADIO WAVE ABSORPTION IN THE LOWER IONOSPHERE OVER EUROPE

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INTRODUCTION

PANCHEVA et al. (1989) analysed variations of radio wave absorption in the lower ionosphere at 5 LF radio paths (A3 method - oblique incidence on the ionosphere) in Central and Southern Europe. They found several ranges of dominant periods between 2-15 days. However, all are of meteorological origin and the "solar" period $T \simeq 13.5$ day (half of the solar rotation period) has not been observed with the expected amplitude.

In order to clarify the question of "solar" periods in absorption, we study the pattern of the solar Lyman-alpha radiation (the principal ionizing agent of the lower ionosphere) and of the radio wave absorption at five widely spaced places in Europe. We use the A3 absorption at 1539 kHz (Panská Ves, f_{eq} = 650-700 kHz, reflection point 50.3°N, 11.8°E) and twice at 2830 kHz (El Arenosillo, f_{eq} = 1.2 MHz, reflection point 38.5°N, 5.3°W; Ebro Observatory, f_{eq} = 1.4 MHz, reflection point 40.6°N, 1.6°W), and the f_{min} parameter (an indirect measure of absorption) from Moscow (55.5°N, 37.3°E) and Rostov upon Don (47.2°N, 39.7°E). We investigate two consecutive periods, March-June 1982 and July -October 1982. The former displays a very suppressed 27-day variation in Lyman-alpha. The 13.5-day variation seems to prevail (Figure 1). The latter displays a pure solar rotation variation in Lyman-alpha (Figure 2) with the largest amplitude observed during the whole 21st solar cycle.

RESULTS

The period March-June 1982 (Figure 1) displays rather poor similarity in development of Lyman-alpha and both absorption and f_{min}. Some gaps in data are caused by solar flares (SWF) and by technical problems. The lower frequency cut-off of f_{min} (1.0 MHz Moscow, 1.4 MHz Rostov) is given by the technical characteristics of ionosondes. Some increases of absorption and f_{min} are due to a considerable increase of the background X-ray flux and to the occurrence of weaker X-ray bursts, which enhance the absorption but are not strong enough to create a clear SWF. Such increases are observed e.g. on June 12-13 (1539 kHz), June 11 (El Arenosillo) or June 15-16 (f_{min}).

In order to support "visual" results from Figures 1 and 2, the correloperiodogram analysis (KOPECKÝ and KUKLIN, 1971) of the Lyman-alpha radiation, absorption (1539 kHz) and f_{min} (Moscow) was performed in the period range of 2-32 days for both periods. As to the period March-June 1982, for Lyman-alpha it yielded two dominant periods 26.5-27 and 13-13.5 days at the confidence level of 0.01 with equal amplitudes of 0.105 (in units of Figure 1), and a less important period of 21 days (confidence level 0.05, amplitude 0.064). The period late March-June was dominated by T = 13.5 day. The f_{min} parameter displayed three periods at the 0.1 confidence level, 10.5, 13 and 19 days with amplitudes 0.044, 0.044 and 0.046, respectively. Owing to the low confidence level and to the step of 0.1 MHz in determining f_{min}, they all appear to be rather insignificant. The absorption exhibits two periods, 32 days (0.01 confidence level, 2.95 dB amplitude) and 17.5 day (0.1 confidence level, 2.2 dB amplitude). Thus both ionospheric parameters display periods different from those observed in Lyman-alpha. This confirms the conclusion drawn from Figure 1 about a poor similarity between the time-development of Lyman-alpha and ionospheric parameters.

Figure 2 shows that during the period of a well-developed solar rotation variation in July-October 1982 there is a remarkable similarity between variations of the solar Lyman-alpha radiation, radio wave absorption (except for Ebro data in late August - early September) and f_{min}. The correlation is again perturbed by the factors discussed in relation to Figure 1, but also by the post-storm effects of three strong magnetic storms (marked by S in Figures 1 and 2) with $K_p$max > 8, particularly by those in September. The effect of the very strong proton flare of July 11 (PF in Figure 2) coincides with the maximum of the Lyman-alpha flux.

The correloperiodogram analysis of the Lyman-alpha radiation, absorption (1539 kHz) and f_{min} (Moscow) for the period July-October 1982 yields in all three parameters the dominant solar rotation period at the confidence level of 0.01 - 25.5 day (amplitude 0.39) in Lyman-alpha, 25.5 day (amplitude 6.4 dB) in absorption and 24.5 day (amplitude 0.15 MHz) in f_{min}. The spacing between the consecutive Lyman-alpha maxima in Figure 2 is 24, 27, 24 and 27 days, i.e. just 25.5 day on average. The amplitude of solar rotation oscillations is in all three parameters much larger than that for any periodicity in the March-June period. Other periods - 13 days in Lyman-alpha (0.05 confidence level, 0.099 amplitude) and 19 days in both absorption (0.05 confidence level, 2.6 dB amplitude) and f_{min} (0.1 confidence level, 0.06 MHz amplitude) - are much weaker than the solar rotation oscillations.

CONCLUSION

When the solar Lyman-alpha flux variability is very well developed (July-October 1982), then it dominates in the lower ionospheric variability. The most pronounced Lyman-alpha variation on time scale day-month is the solar rotation variation (about 27 days). When the Lyman-alpha variability is developed rather poorly, as it is typical for periods dominated by the 13.5 day variability, then the lower ionospheric variability appears to be dominated by variations of meteorological origin. This fact and the considerably varying amplitude of the 13.5 day solar oscillation are probably the reason why T = 13.5 day was not found by PANCHEVA et al. (1989) to be of primary importance in the lower ionospheric variability. The above conclusions hold for all five widely spaced places in Europe. The interesting 19-day variability will

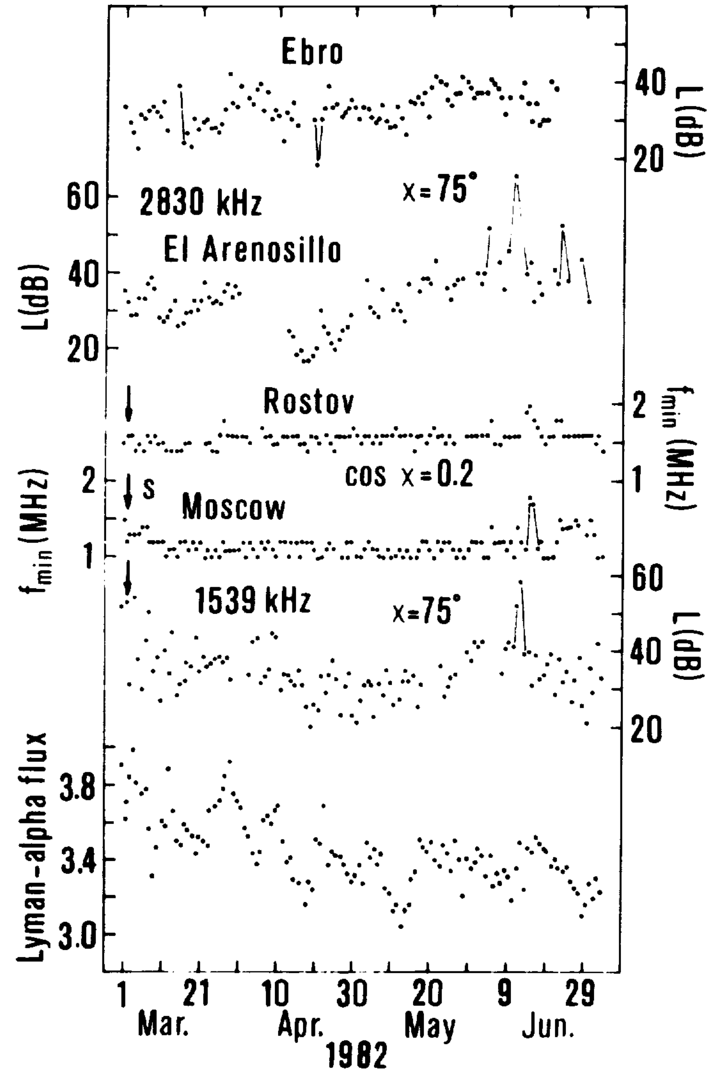

Fig. 1. Lyman-alpha flux, radio wave absorption (three A3 circuits) and f_{min} (Moscow and Rostov upon Don) during the period of suppressed 27-day variation in Lyman-alpha (March-June 1982). The Lyman-alpha flux is in 10^{11} photons/cm^{-2} s^{-1}. S - strong geomagnetic storm ($K_p$max = 8).

be studied in more detail in another paper.

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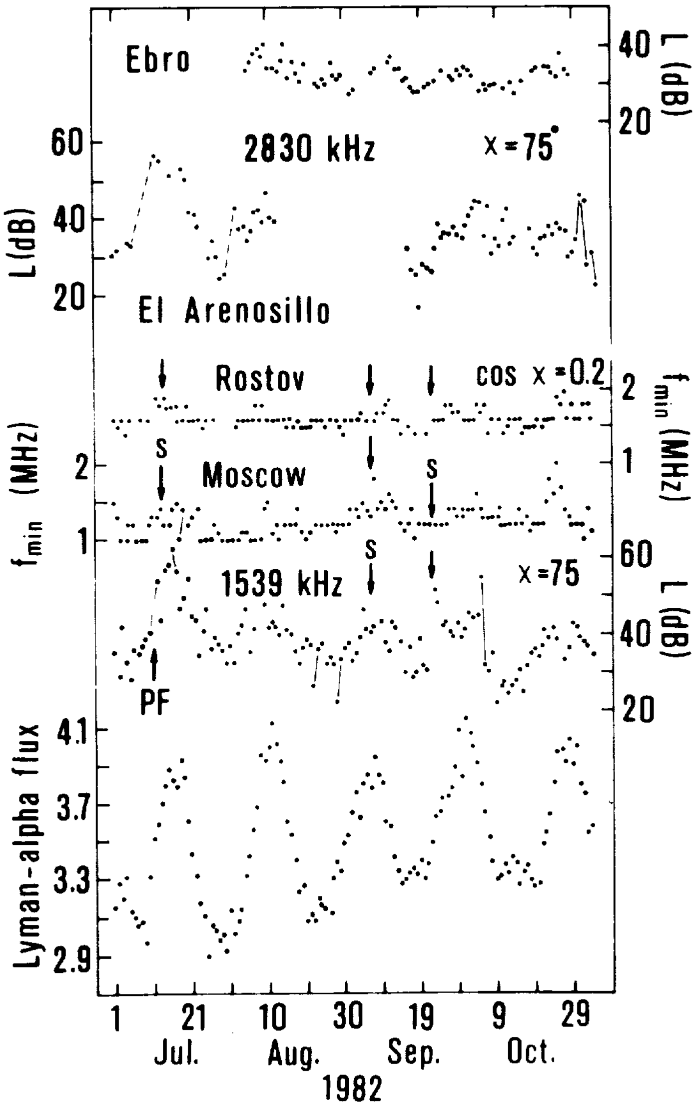

Fig. 2. The same as Figure 1 for the period of the well-developed solar rotation variation in Lyman-alpha (July-October 1982). S - strong geomagnetic storms ($K_p\mathrm{max} \geq 8$). PF - strong proton flare.

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