METEORIC HEAD ECHOES

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Abstract. Results of the analysis of 3261 radar meteor head echoes observed during the Orionid and Lyrid periods by the high-power radar of the Springhill Meteor Observatory are given. Dependence of the occurence of head echoes on the geometrical factors and physical properties of the meteoroids has been studied. Increas of the head echo rates with the elevation of the shower radiant and with the velocity of meteoroids has been observed.

1. Introduction

They were many attempts to explain the behaviour of meteoric head echoes, characterized by their high radial velocities and very short durations on the range-time radar record. Many of them have been summarized recently by Jones and Webster (1991), stressing no sitisfactory explanation after more than four decades of observations. Rajchl (1965) observed some connection between the head echo phenomenon and the forbidden line of oxygen on the wavelength of 557.7 nm. Both correspond to the same atmospheric heights, both appear preferebly with the meteors of higher geocentric velocity, their intensity is constant along the whole trail and they depend on the atmospheric conditions at meteor heights. Hawkes and Jones (1975, 1978) suggest that meteoroid fragments produce either water cluster ions or some similar fragile molecular ions, which are effective in removing the ionisation in a short time. Then the ablation mechanism of individual grains, separated from the main meteoroid body could be responsible for the expanding head of the ionized trail. Jones and Webster (1991), analysing visual and radar data, have found that the fraction of head echoes observed, is proportional to the geocentric velocity of the meteor. Hajduk (1972, 1973) has shown that the proportion of head echoes to the whole observed radar echoes in meteor showers is higher during their periods of maxima, but in the same time they depend on the elevation angle of the meteoroid, decreasing with the decreasing zenithal distance of the shower radiant. Therefore, there is difficult to ascribe the occurence of a meteoric head echo exlusively to the composition of a meteoroid.

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2. Observational data and results

Our observational data consist of 3261 meteoric head echoes, recorded with the high-power (megawatt) radar of the Springhill Meteor Observatory during the period of Lyrid (22.4. - 23.4.1971) and Orionid (21.10. - 23.10.1971) meteor showers. Head echoes with shifts in range dR < 3 km have been eliminated. In 48 hours during the Orionid period, 2556 head echoes were recorded and only 705 in 36 hours during the Lyrid period. The equipment characteristics have been described by Neale (1966), the main characteristics being: the peak power output of 4 MW at the frequency of 32.7 MHz, pulse length of 12 microseconds and repetition frequency of 120 Hz. Film records (30 m × 3.5 mm) of the cathode raytube (with the velocity of 10 cm/min) have been obtained and reduced.

The first result, which can be seen on the first glance, is the almost 2.5 times higher rate of head echoes during the Orionid period in comparison with the Lyrid period, when same time intervals are taken. The dependence of the occurence of head echoes on the velocity, shown by Jones and Webster (1991) appears here even much steeper.

The range distributions of the head echoes recorded are shown in Figures 1 and 2 for the Lyrids and Orionids respectively, separately for each day. It

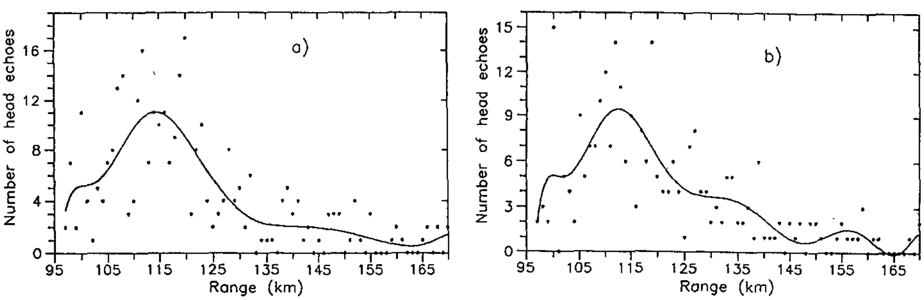

Fig. 1: Range distributions of the beginnings of head echoes during 1971 Lyrid shower – a) Apr. 22, b) Apr. 23 – with best fit lines (polynomial of 10th degree).

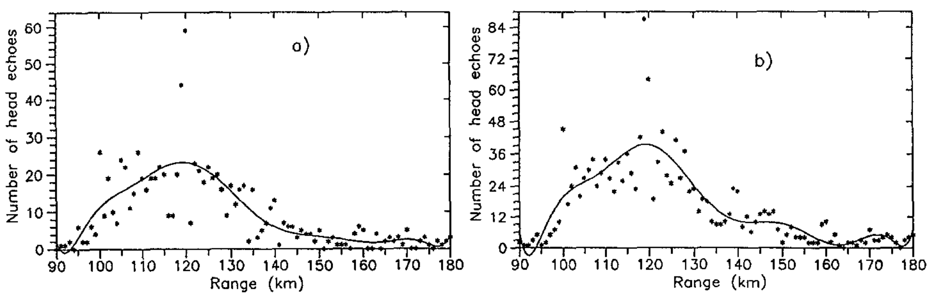

Fig. 2: Range distributions of the beginnings of head echoes during 1971 Orionid shower - a) Oct. 21, b) Oct. 22 - with best fit lines (polynomial of 10th degree).

is seen, that the range interval of the Orionids, with the maximum number of head echoes, placed to 120 km, is in comparison with the Lyrids (maximum at about 114 km) shifted towards the lower elevation echoes. However this shift may be caused also by the corresponding change in atmospheric heights of the echo beginnings, which are considerably higher for faster Orionids.

This is more effectively shown in Fig. 3, comparing range distribution of head echoes in the Orionid period, for the time interval with low elevation of the shower radiant compared with the time of radiant culmination. The sporadic maximum of head echo rates at about 105 km is clearly distinguished from the shower maximum at about 120 km. Low head echo rates obtained at the culmination time from the Ondřejov radar data (Hajduk 1972) can be explained by the beam axis elevation, fixed in elevation of 45° at Ondřejov, in comparison with the omnidirectional antenna used at Springhill.

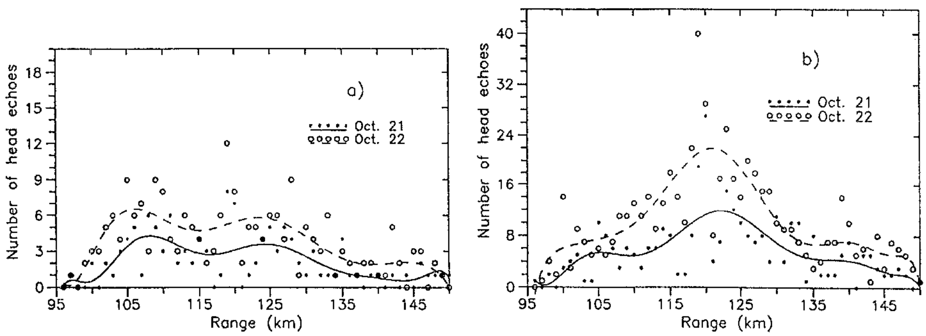

Fig. 3: Range distributions of the beginnings of head echoes during 1971 Orionid shower (with fit lines) at time intervals: a) t ∈ ⟨3; 7) UT, b) t ∈ ⟨8; 12) UT

At least three conclusions can be made from above analysis: the meteoric head echo is a phenomenon, connected with the motion of the meteoroid through the atmosphere and recorded on the range-time display of radar equipment, occurence of which depends

1) on the ablation process connected with the amount of porous particles, released from the meteoroid body,

2) on the geocentric velocity of the meteoroid

3) on the recording system characteristics, as beamwidth and beam orientation.

The study of meteoric head echoes in close connection with drifting meteor echoes, showing radial velocities of 1 order less than head echoes (Hajduk and Prikryl 1976, Lindblad and Hajduk 1984) may substantially broaden our knowledge in meteor physics.

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