METEOR ECHO DRIFTS AND ECHO DURATION

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Abstract: Analysis of the duration and radial components of the velocity of 215 echoes showing drift on the range-time radar record confirm the interpretation of echo drifts in terms of the motion of the effective reflexion point along the meteor trajectory.

1. Introduction

The evidence of the motion of the effective reflexion point along the meteor train, towards the region of maximum ionization of the train, has been demonstrated in our analysis of 44 head echoes followed by drifting body echoes on the range-time radar record (Hajduk and Prikryl, 1976). We have also noted that the confirmation of the mechanism of the motion of the effective reflexion point by the relation between the echo duration and the velocity of the echo motion is not convincing, since the shorter is the echo duration, the more velocities become indeterminate due to a very slight change in range. The same effect should appear in the analysis of the linear variations of the Doppler frequency on the records obtained by a continuous radio technique made by Rao and Armstrong (1958). The calculated velocities of the echo drifts were found to be higher in the case of shorter echo durations and vice versa. Better agreement of the experimental values with the calculated theoretical curves was achieved by Rao and Armstrong, when the effect of turbulence was taken into account. It should be noted that the effect of missing echoes due to a very small change in frequency for short duration echoes was not considered there and hence the experimental values can be changed considerably, by the contribution of the small velocities of short duration echoes.

The present paper confirms the theory of the motion of the effective reflexion point along the meteor train by estimating the effect of missing low-velocity echoes for which the radial motion becomes unmeasurable.

2. Observations

A total of 215 radar meteor echoes producing a small displacement in range during a part of the echo life-time or during the whole life-time, have been observed during the periods of Oct. 19—24, 1961, Oct. 16—27, 1962, Oct. 21—23, 1963 and Oct. 14—22, 1965 with the radar equipment of the Astronomical Institute of the Czechoslovak Academy of Sciences at the Ondřejov Observatory.

The radial velocities of echoes have been calculated in the same way as in the previous paper (Hajduk and Prikryl, 1976). The difference is that the body echoes presented here are not connected with head echoes. For a few echoes two different components of the radial velocity of the opposite sign have been found, and both were taken into analysis. The radial velocities of echoes are plotted against the echo durations in Fig. 1. The distribution of radial velocities of echoes along the scale of the echo duration in Fig. 1 is roughly identical with the distribution of vertical components of the echo velocities within the same duration range, as deduced by Rao and Armstrong (1958, see Fig.11).

3. Analysis

The velocity-duration plot of echoes presented in Fig. 1 shows blank areas in the number distribu-

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tion of echoes, when approaching the rectangular coordinate axes, especially the short durations and the small velocities. This fact is a consequence of the impossibility of measuring a very slight displacement for a short duration echo. The accuracy of the computed values of radial velocities is given by the errors of reading off of the echo image and number of drifting echoes of velocity v_r for each duration class in the form $v_r = a - b \ln \frac{N_{v(b)}}{N_\tau}$ (where a, b are positive constants), we have estimated the proportion of missing echoes for each duration class. From this analysis it was found that nearly one hundred echoes had been

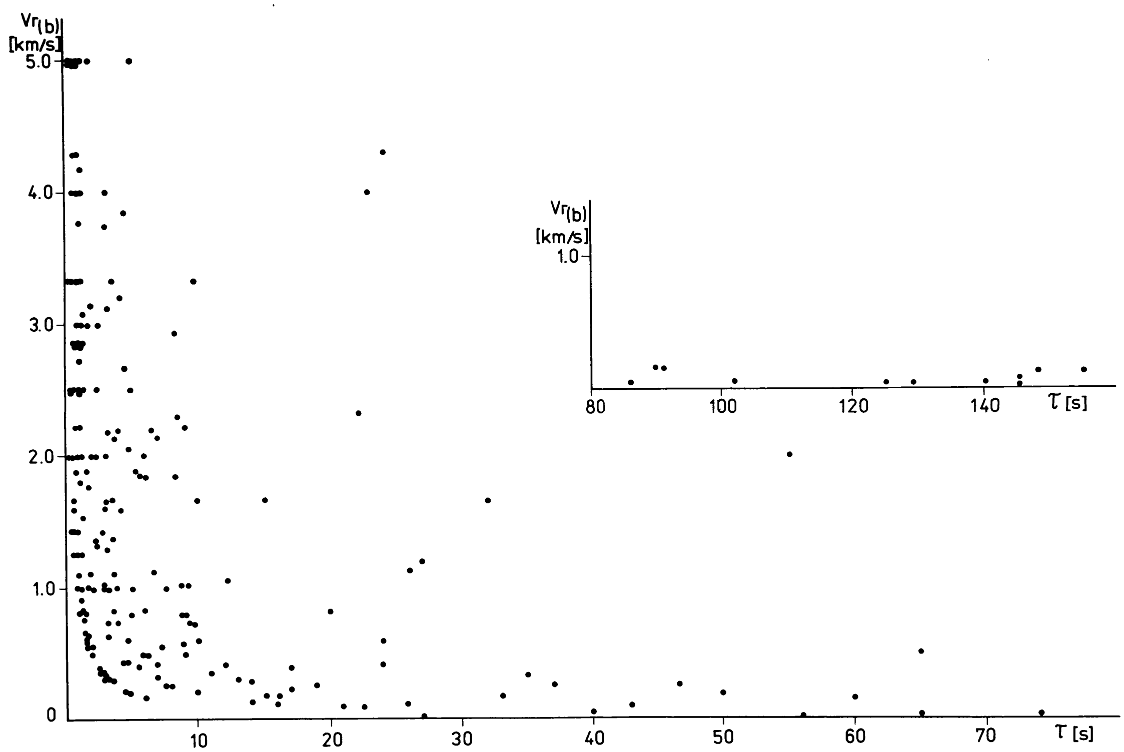

Fig. 1. Radial velocities $v_{r(b)}$ and durations τ of drifting echoes.

its changing position on the film record projected on the screen; in most cases the errors are at about ± 0.5 km in range and ± 0.05 s in time. Taking into account these errors and the vertical size of the echo image on the record we cannot determine shifts in the range $\Delta R < 1$ km for echo durations $\tau < 1$ s.

To assess the missing drifts we have divided our set of data into five duration classes. For each interval of echo duration we have plotted the number of echoes against the measured radial velocity of the echo drift. The number of echoes increases rapidly towards small velocities but then it drops abruptly to zero. Assuming a logarithmic dependence between the radial velocity v_r and the lost due to the unmeasurable shift on the range-time record. Nearly one half of them belongs to the class of durations shorter than 1 second. The number of missing echoes rapidly decreases towards longer durations.

However the number of missing echoes may be still underestimated, especially for the class of the shortest durations. The relative numbers of drifting echoes of the selected velocity class N_v to all drifting echoes N_τ of each duration class are plotted in Fig. 2 — uncorrected (a) and corrected for missing echoes (b).

As it is seen from Fig. 2 the relative number of drifting echoes remains significantly higher for the long duration echoes and small velocities and

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significantly smaller for long duration echoes and high velocities even after the corrections applied for the technique of detection.

One more effect could be considered as an the theory of the motion of the effective reflexion point along the meteor train, according to which the velocity of the motion of the effective reflexion point is inversely proportional to the duration of

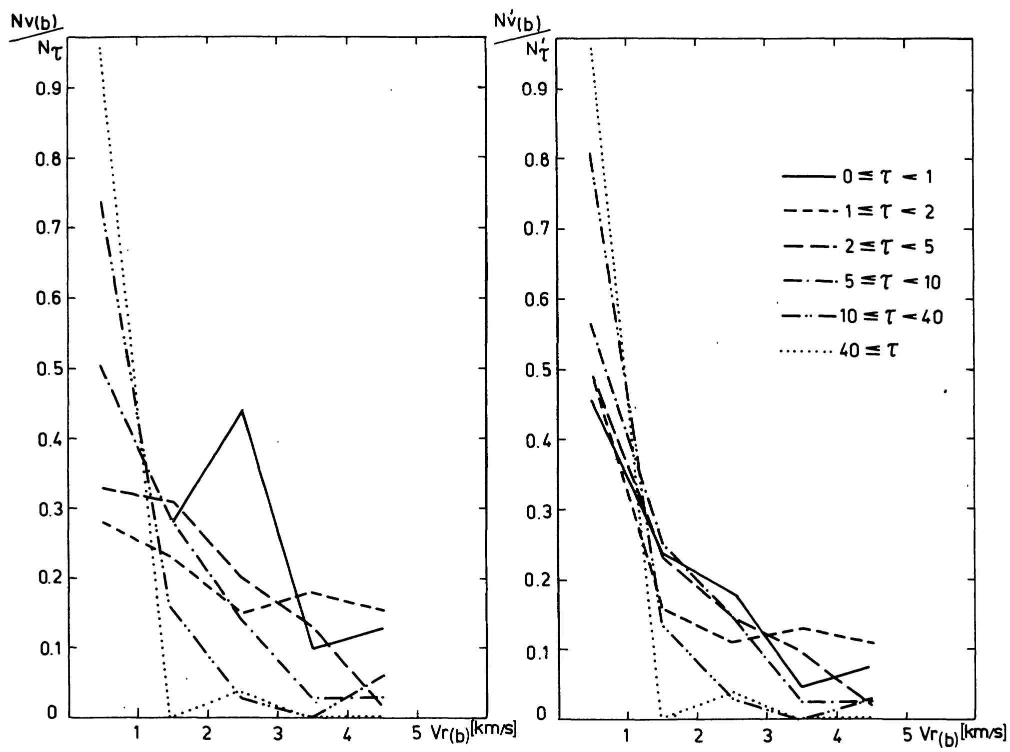

Fig. 2. Distribution of drifting echoes in velocity and duration classes. $N_{v(b)}$ — number of drifting echoes of the selected velocity class, N_τ — number of all drifting echoes of selected duration class; $v_{r(b)}$ — radial velocity of drifting echoes; N — uncorrected, N' — corrected values.

effect influencing the dependence shown in Fig. 2. In some cases of the measured long enduring echoes, especially in cases of echoes which follow after head echoes a deceleration of the drift can be observed. A drift is often slowed down to a certain value and then it continues with a nearly constant velocity. If average velocities are measured, as in our analysis, the resulting values are much less than they really are. As a consequence of this effect, we would obtain smaller differences in the relative echo numbers in Fig. 2 between the duration classes at higher velocities. In spite of this, the resulting distribution of drifting echoes presented in Fig. 2 meets satisfactorily the requirement of the train. The importance of this conclusion consists in the fact that the deduced relation between the echo duration and the radial velocity of the echo drift is an independent confirmation of the interpretation of echo drifts in terms of the motion of the effective reflexion point along the meteor train.

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Súhrn

Na základe analýzy trvaní a radiálnych rýchlostí 215 meteorických ozvien, pri ktorých sa zistil pohyb na vzdialenostno-časovom zázname radaru, v práci sa potvrdzuje interpretácia pohybov ozvien ako pohybu efektívneho bodu odrazu pozdĺž meteorickej stopy. Rýchlosť pohybu ozveny je nepriamoúmerná trvaniu ozveny, čo je v súlade s teóriou pohybu odrazového centra na meteorickej stope.

ДРЕЙФ МЕТЕОРНЫХ ЭХО И ДЛИТЕЛЬНОСТЬ ЭХО

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Резюме

На основании анализа длительностей и лучевых составляющих скоростей 215 метеорных эхо, показывающих дрейф на дальностно-временной развертке, подтверждается интерпретация дрейфа эхо как движения центра эффективного отражения вдоль метеорного следа. Скорость движения эхо обратно пропорциональна длительности эхо, что соответствует теории движения эффективного центра отражения вдоль следа метеора.

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