= Earth @-@ grazing meteoroid of 13 October 1990 =

The Earth @-@ grazing meteoroid EN131090 of 13 October 1990 was a meteoroid with an estimated mass of 44 kg that entered Earth 's atmosphere above Czechoslovakia and Poland and , after a few seconds , returned to space . Observations of such events are quite rare ; this was the second recorded using scientific astronomical instruments (after the 1972 Great Daylight Fireball) and the first recorded from two distant positions , which enabled the calculation of several of its orbital characteristics . The encounter with Earth significantly changed its orbit and , to a smaller extent , some of its physical properties (mass and structure of its upper layer) .

= = Observations = =

Visual observations were reported by three independent comet observers : Czech astronomers Petr Pravec , Pavel Klásek , and Lucie Bulí?ková . According to their report , the event started at 03 : 27 : 16 ± 3 UT and the observed bright meteor (fireball) was moving from the south to the north . It left a track that was visible for 10 seconds .

Most data about the encounter was acquired using photographic observations by cameras of the European Fireball Network . It was the first event of this type recorded by cameras from two distant locations , at ?ervená hora and Svratouch (both in what is now the Czech Republic) , which enabled the calculation of the meteoroid 's orbital characteristics by geometrical methods . Both were equipped with all @-@ sky fisheye objectives .

The ?ervená hora image was especially valuable . It recorded the fireball 's trajectory over approximately 110 ° , starting 51 ° above the southern horizon , passing the zenith just 1 ° westward and disappearing only 19 ° above the northern horizon (thus crossing about 60 % of the sky) . Its camera was also equipped with a rotating shutter that interrupted the exposure 12 @.@ 5 times per second and divided the captured track of the fireball , allowing the determination of its speed . Over the last 4 ° , the fireball 's angular velocity was lower than the resolution of the instrument . The Svratouch image recorded the trajectory only for about 15 ° , beginning at 30 ° above the northwest horizon , and the pictured fireball was quite weak . Despite this , the data were sufficient for the calculations .

Gotfred M. Kristensen also detected the fireball in Havdrup , Denmark , using a pen recorder connected to a radio receiver for 78 seconds , at 03 : 27 : 24 ± 6 UT .

= = Encounter data = =

The meteoroid grazed Earth 's atmosphere quite gently (in comparison to , for example , the 1972 Great Daylight Fireball above the United States and Canada) . It became visible at a height of 103 @.@ 7 km north of Uherský Brod , Czechoslovakia , only approached Earth 's surface to 98 @.@ 67 km northeast of Wroc?aw , Poland , and disappeared from the sight of the cameras at a height of 100 @.@ 4 km north of Pozna? , Poland . It would probably still have been visible until it reached a height of 110 km above the southern Baltic Sea .

The meteoroid 's absolute magnitude (the apparent magnitude it would have at an altitude of 100 km at the observer 's zenith) was approximately ? 6 and did not vary significantly during the encounter . It travelled a distance of 409 km in 9 @.@ 8 seconds during the time it was observed . It was moving with a speed of 41 @.@ 74 km / s , which did not change during the flight . Ji?í Borovi?ka and Zden?k Ceplecha from the Ond?ejov Observatory in Czechoslovakia estimated that the deceleration caused by the friction of the atmosphere was only 1 @.@ 7 m / s2 near the fireball 's perigee (closest approach to Earth) , which meant that its velocity was reduced by only 0 @.@ 012 km / s . This corresponds well with computer simulations provided by D. W. Olson , R. L. Doescher and K. M. Watson at the Southwest Texas State University , who concluded that the meteoroid was practically not decelerated along its trajectory , with the exception of a very short time near perigee , when the deceleration was 1 m / s2 .

The software also calculated the fireball 's instantaneous apparent magnitude at the ground . The

computation started and ended with heights of approximately 250 km , long before and after the cameras of the European Fireball Network could observe it . Its apparent magnitude started at a value of + 5 @.@ 7 and it became brighter quite quickly . The program gave an apparent magnitude of ? 5 @.@ 7 when it was seen by one camera and ? 6 @.@ 3 at perigee . The fireball subsequently dimmed , with an apparent magnitude of ? 5 @.@ 4 when it was last seen by the cameras and a final calculated value of + 6 @.@ 0 at a height of 257 km . However , these values are not entirely certain , because the program worked with the simplified assumption that the luminous efficacy of the fireball did not change along the track . The starting apparent magnitude is not far from the naked eye visibility limits . For example , faint stars of the magnitude + 6 can can be observed only in dark rural areas approximately 150 km far from big cities . For comparison , this magnitude corresponds to the apparent magnitude of Uranus . At its brightest , it was several times as bright as the maximum brightness of Venus .

= = Physical characteristics = =

The meteoroid was a type I fireball , i.e. an ordinary chondrite . When it entered Earth 's atmosphere its mass was about 44 kg , which was estimated on the basis of the measured values of its absolute magnitude and velocity . It lost approximately 350 g during the encounter . Computer simulations showed that it started losing mass approximately at the moment it became visible to the cameras of the European Fireball Network , at a height of 100 @.@ 6 km . It lost mass for 25 seconds , until it reached a height of 215 @.@ 7 km . Its surface melted and solidified again after leaving , which means its surface became a typical meteoritic fusion crust .

The meteoroid was not dangerous to the life on Earth . Even if it had headed towards lower parts of the atmosphere it would have heated so much that it would have exploded high above the ground and only some small particles (meteorites) eventually might have made it to Earth 's surface .

= = Orbit = =

Because the fireball was recorded by two cameras of the European Fireball Network , it was possible to calculate the trajectory of its flight through the atmosphere , and afterward also the characteristics of both its pre- and post @-@ encounter orbit in the Solar System . The calculations were published by Czech astromers Pavel Spurný , Zden?k Ceplecha , and Ji?í Borovi?ka from Ond?ejov Observatory , who specialize in meteor observations . They proved that the encounter changed the meteoroid 's orbit significantly . For example , its aphelion (the farthest it travels from the Sun) and orbital period were lowered to almost half of their original values .

= = Similar events = =

Although entries of meteoroids into Earth 's atmosphere are very common , recording a similar flight through the upper layers of the atmosphere is quite rare . Probably the first one reliably verified happened on 20 July 1860 above the American state of New York . The Czechoslovak ? Polish fireball is sometimes compared to the 1972 Great Daylight Fireball above Utah , the United States , and Alberta , Canada , which is the first scientifically observed and studied event of this type . The 1972 fireball was more than a thousand times more massive and it got 40 km closer to Earth 's surface . Observational data from both of them helped to develop a method for computing the grazing trajectories of such bodies , which was later used when calculating the trajectory of another Earth @-@ grazing meteoroid , observed on 29 March 2006 above Japan .