Asteroidal Meteors detected by MU Radar Head-echo Observations

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Introduction

High power large aperture (HPLA) radar observation is a technique to provide useful information on meteor influx, orbits, and interaction processes with Earth's atmosphere. The recent development of the technique carried out using the middle and upper atmosphere radar (MU radar) of Kyoto University at Shigaraki (34.9N, 136.1S), which is large atmospheric VHF radar with 46.5 MHz frequency, 1 MW output transmission power and 8,330 m2 aperture array antenna, has established very precise orbital determination from meteor head echoes. We have revolutionary achieved to determined the precise orbit of meteoroids using meteor head echo with the MU radar which is as good as (or better than) those observed by optical observations. A tremendous number, more than 150,000, of observed orbits of meteoroids by the MU radar meteor head-echo observation will shed light on new discoveries of meteoroids. Here we report some interesting features related with asteroids or distinct comets.

Results

Fig 1 shows orbits of Geminids (n=819) and Quadrantids (n=44) derived from MU radar under the condition of D_{sh}<0.1. If the orbital dissimilarity criterion, D_{sh} between two orbits are small enough, both objects are likely to be a dynamical association. D_{sh}<0.2 usually used to find meteor shower associations. In 2013, ten simultaneous TV observations of Geminids were detected by amateur meteor observing cameras operated by Sonotaco network. Table 1 shows examples of derived orbital elements of 2013 Geminids detected by radar and optical cameras. The radar orbits amazingly agree with optical observations.
Fig 2 shows the distribution of beginning height classified by using Ceplecha's *Kb* parameter [4] which indicates the strength of meteoroids. Most of small eccentricity and low inclination meteoorids are categolized as

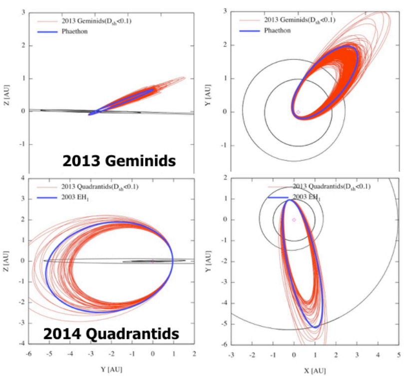

Fig 1 Orbits of 2013 Geminids and 2014 Quadrantids.

Table 1 Comparison of orbits between radar and optical determinations. The orbital elements of 2010 Geminids observed by the MU radar [3] and parent body (3200) Phaethon are also compared.

Object	*Date*	a	e	*i*	*ω*	*Ω*	D_{sh}
	UT	au	–	°	°	°	–
Phaethon	-	1.27	0.89	22.2	322.1	265.2	-
1-radar	Dec/14	1.27	0.89	23.6	325.1	262.6	0.013
1-opt	15:29	1.22	0.88	23.5	325.1	262.6	
2-radar	Dec/13	1.20	0.89	24.1	325.8	261.7	0.030
2-opt	18:49	1.39	0.91	23.2	325.8	261.7	
3-radar	Dec/13	1.21	0.89	22.5	324.5	261.6	0.037
3-opt	16:14	1.26	0.88	22.7	324.5	261.6	
Geminids	2010	1.30	0.899	25.0	326.1	262.3	-

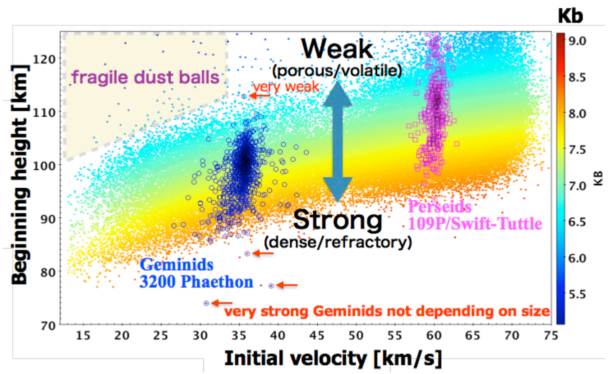

Fig 2 Strength of Meteoroids classified by Ceplecha' s *Kb* parameter[4].

Fig 2 shows the distribution of beginning height classified by using Ceplecha's *Kb* parameter [4] which indicates the strength of meteoroids. Most of small eccentricity and low inclination meteoorids are categorized as asteroidal *Kb*>8.0. 'Fragile dust balls' with very slow initial velocity whose beginning heights are extremely high have been discovered. Since the radar observation is biased towards faster speeds, fragile dust balls are one of the majority.

References

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