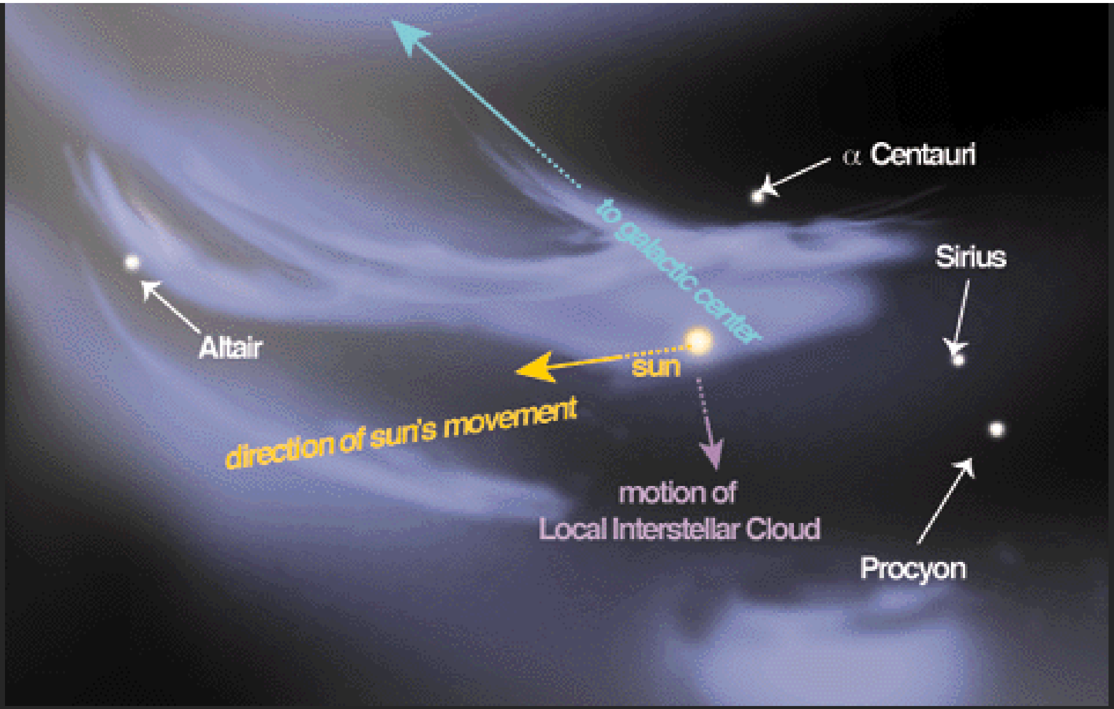
Slovak Academy of Sciences ...science for the future

Mária Hajduková Jr.

Astronomical Institute of the Slovak Academy of Sciences

POPULATION OF HYPERBOLIC METEOROIDS

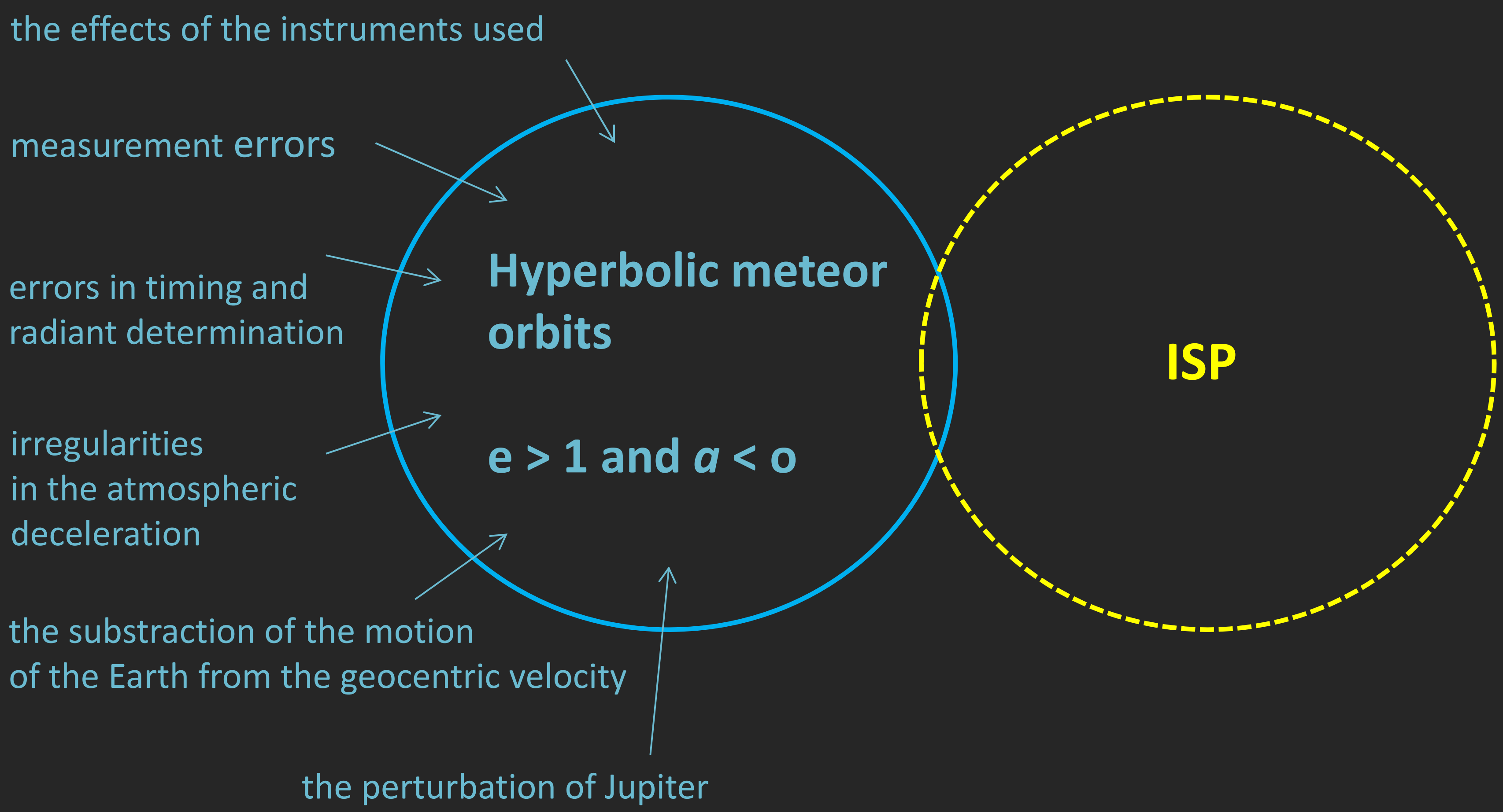


Frish P. et al. 2009: The Galactic Environment of the Sun: Interstellar Material Inside and Otside of the Heliosphere, Space Sci Rev 146, 235

The interaction of the solar system with the interstellar medium should lead to the presence of interstellar particles (ISP).

- **Are ISP present among the registered hyperbolic meteor orbits?**
- **How great is the frequency of ISP according to their masses?**

ERRORS IN THE DETERMINATION OF HELIOCENTRIC VELOCITY:



⇨ the number of possible interstellar meteoroids among the hyperbolic orbits is extremely small

HYPERBOLIC EXCESSES OF ISP

$v_H > v_p$

$\Delta v_H = v_0[(2/r-1/a)^{1/2} - (2/r)^{1/2}]$

$v_i \sim 20\ kms^{-1}$

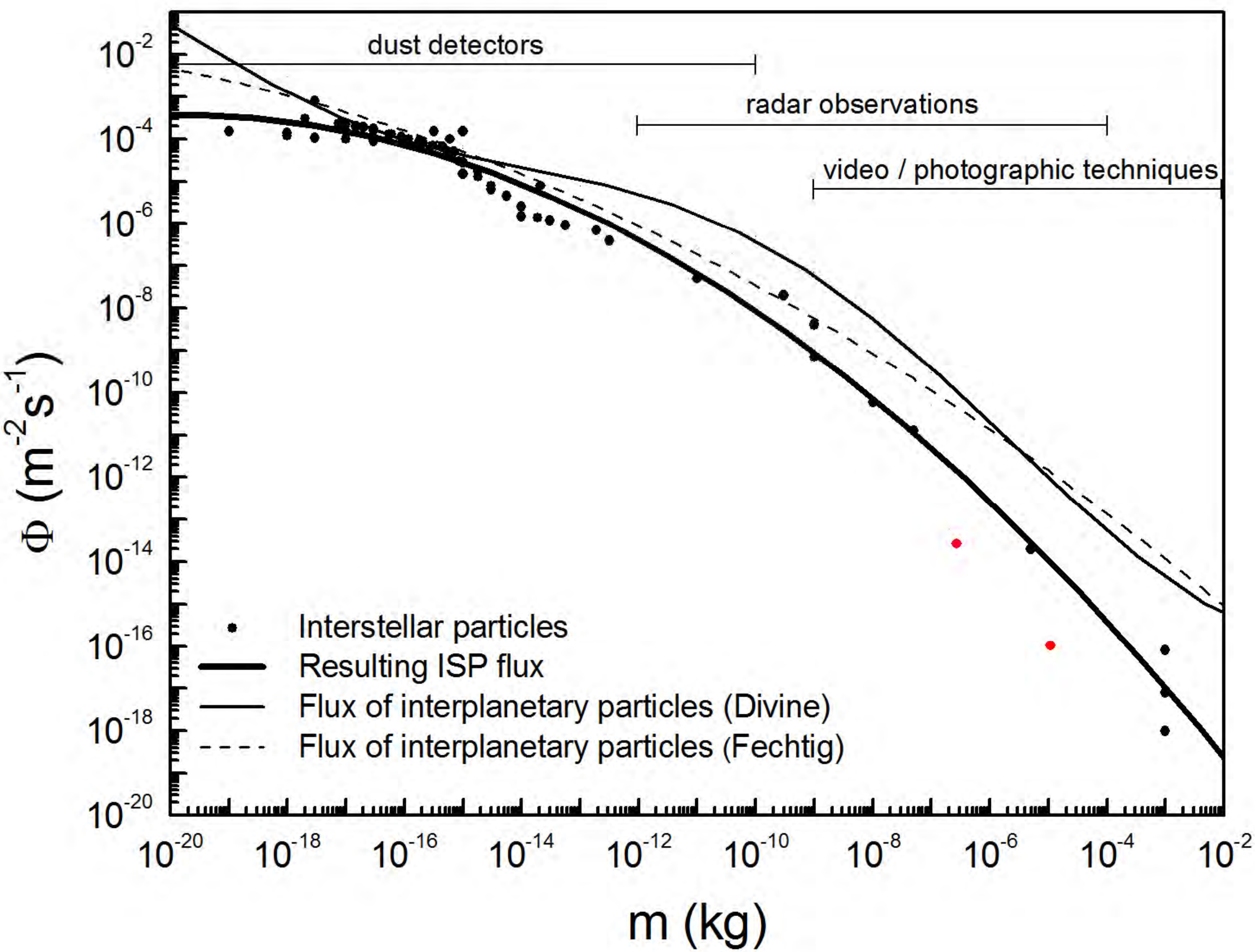
$v_i^2 = v_H^2 - v_p^2$

the heliocentric velocity of an interstellar meteor arriving at the Earth:

$v_H = 46.6\ kms^{-1}$

The overall view of previous studies and observations of interstellar particles using different observation techniques

Source	Observation technique	Flux Φ ($m^{-2}s^{-1}$)	Mass interval Δm (kg)
Baguhl et al. 1996	Cosmic dust detectors, Ulysses a Galileo	1×10^{-4}	6×10^{-16}
Grün 1994	Cosmic dust detectors, Ulysses	1.5×10^{-4}	3×10^{-16}
Grün et al. 1997	Cosmic dust detectors, Ulysses	1.5×10^{-4}	10^{-15} - 10^{-17}
Grün, Landgraf 2000	Cosmic dust detectors, Ulysses	3×10^{-4} - 8×10^{-6}	2×10^{-18} - 2×10^{-14}
Krüger et al. 1999	Cosmic dust detectors, Ulysses	7×10^{-5}	3×10^{-16}
Landgraf et al. 2000	Cosmic dust detectors, Ulysses and Galileo	1.5×10^{-4} - 1.5×10^{-6}	1×10^{-19} - 1×10^{-14}
Landgraf, Grün 1998	Cosmic dust detectors, Ulysses and Galileo	2.2×10^{-4} - 4×10^{-7}	1×10^{-16} - 3×10^{-13}
Landgraf et al. 2000	Radar, AMOR	2×10^{-8}	$> 3 \times 10^{-10}$
Mathews et al. 1998	UHF radar, Arecibo	5×10^{-8}	1×10^{-12} - 1×10^{-9}
Baggaley 1999 a, b	Radar, AMOR	2×10^{-9}	3×10^{-10}
Taylor et al. 1994	Radar, AMOR	4.2×10^{-9}	1×10^{-9}
Taylor et al. 1996	Radar, AMOR	7×10^{-9}	1×10^{-9}
Weryk, Brown 2005	Radar, CMOR	6×10^{-15}	1×10^{-8}
Hajduková, Paulech 2002	Radar catalogue of the IAU MDC	6×10^{-14}	7×10^{-8}
Hawkes, Woodworth 1997	Video technique	6×10^{-11}	1×10^{-8}
Hawkes et al. 1999	Video technique	1.25×10^{-11}	5×10^{-8}
Musci et al. 2012	TV data, CAMO	$< 6 \times 10^{-14}$	$> 2 \times 10^{-7}$
Hajduková 2011	TV catalogue SonotaCo	$< 10^{-16}$	$> 10^{-5}$
Hajduková 1994	Photographic catalogue of the IAU MDC 1987	8×10^{-18}	$> 10^{-4}$
Hajduková, Paulech 2002	Photographic catalogue of the IAU MDC 2001	1×10^{-18}	$> 10^{-4}$
Hajduková 2004	Photographic catalogue of the IAU MDC 2003	7×10^{-19}	$> 10^{-4}$

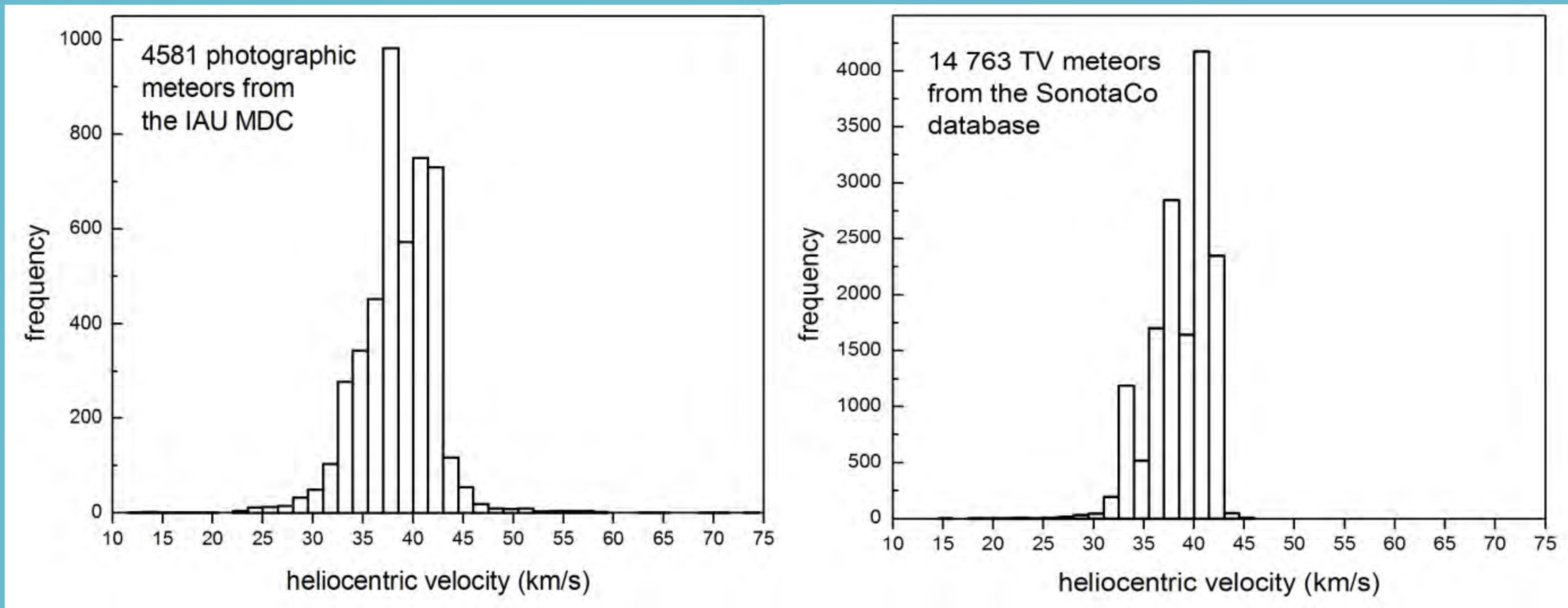


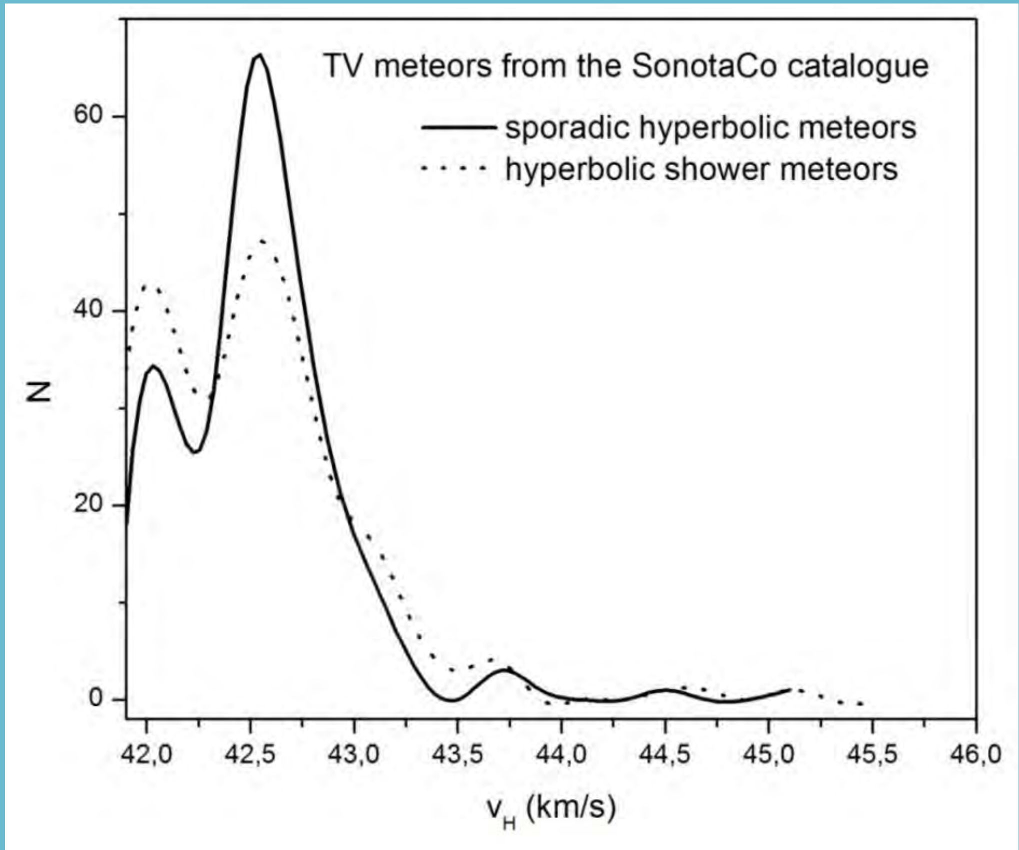
HAJDUKOVÁ, Mária, Jr., HAJDUK Anton, 2006, Mass distribution of interstellar and interplanetary particles, *Contrib. Astron. Obs. Skalnaté Pleso* **36**, 15-25

THE VELOCITY DETERMINATION

An error in the heliocentric velocity $\delta v_H \sim 1\ kms^{-1}$ corresponds to 0.08 – 0.09 AU^{-1} in 1/a.

Such large errors transfer the orbits of meteoroids with high heliocentric velocities over the parabolic limit.


4581 photographic meteors from the IAU MDC
frequency
heliocentric velocity (km/s)
14 763 TV meteors from the SonotaCo database
frequency
heliocentric velocity (km/s)

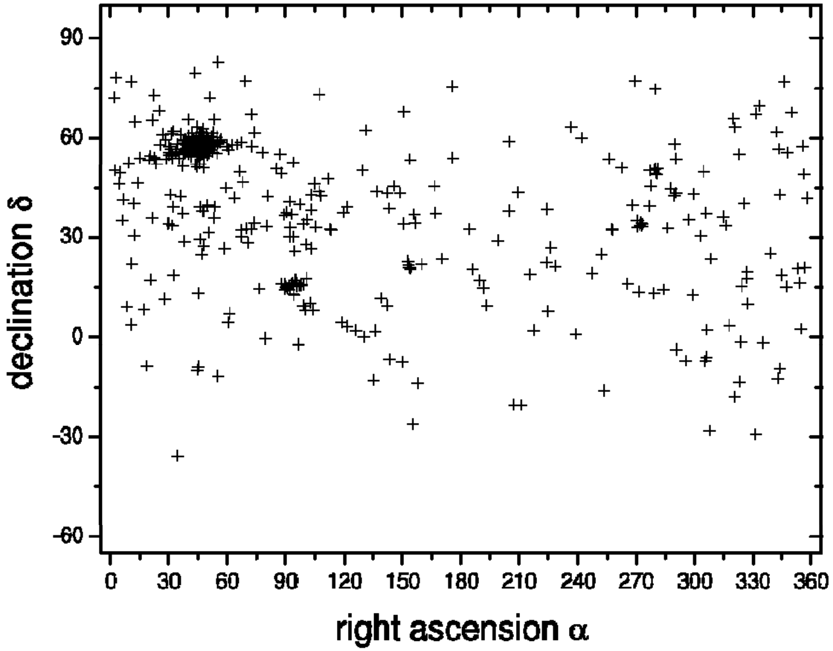


The velocity distribution of meteors with hyperbolic excesses from the SonotaCo database plotted separately for sporadic and shower meteors.

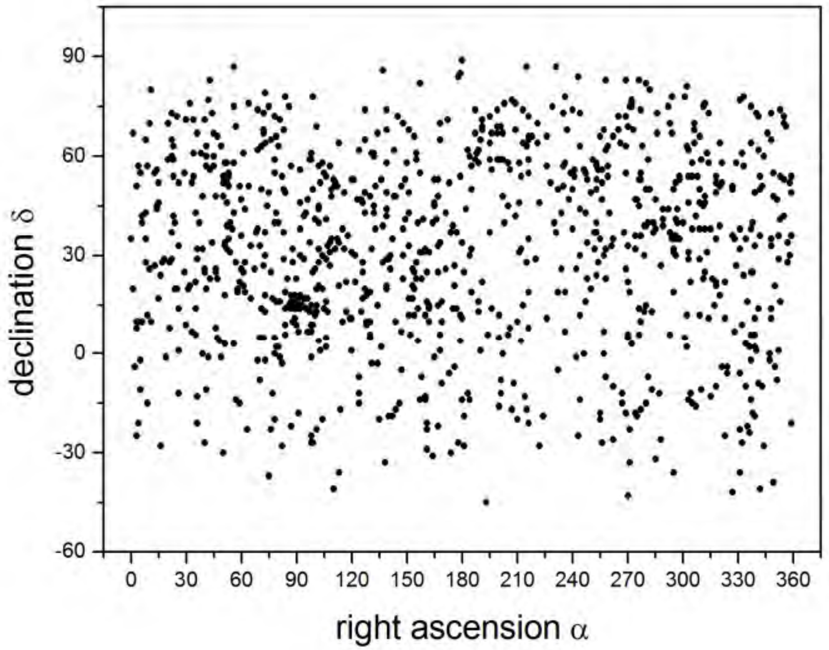
Near the parabolic limit, even a small error in the value of the heliocentric velocity of a meteor can create an apparent hyperbolic orbit.

SHOWER METEORS AMONG THE HYPERBOLIC ORBITS

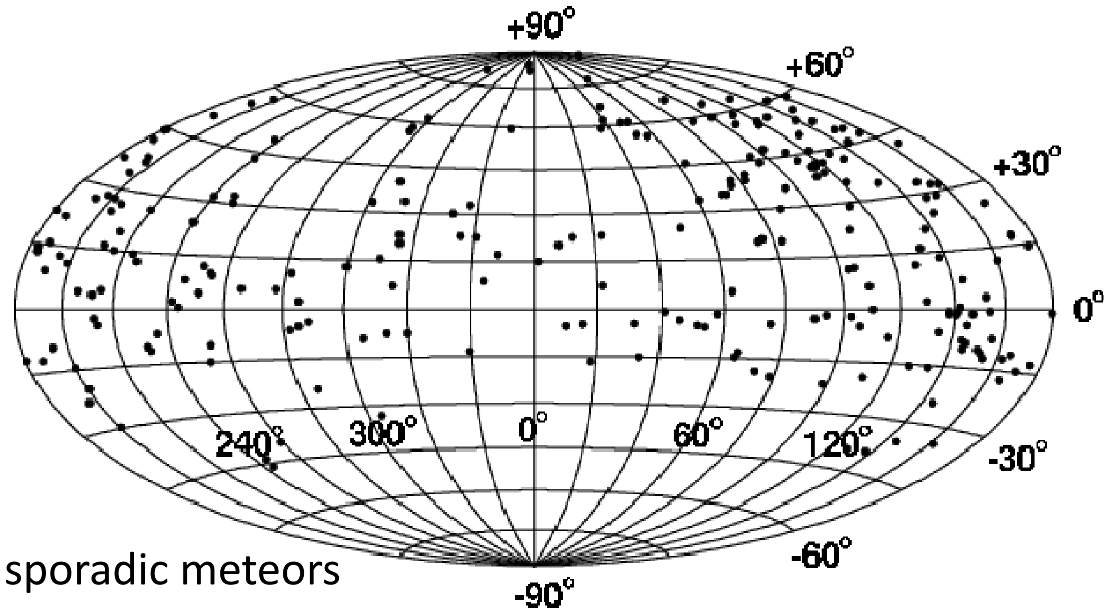
IAU MDC Photographic orbits

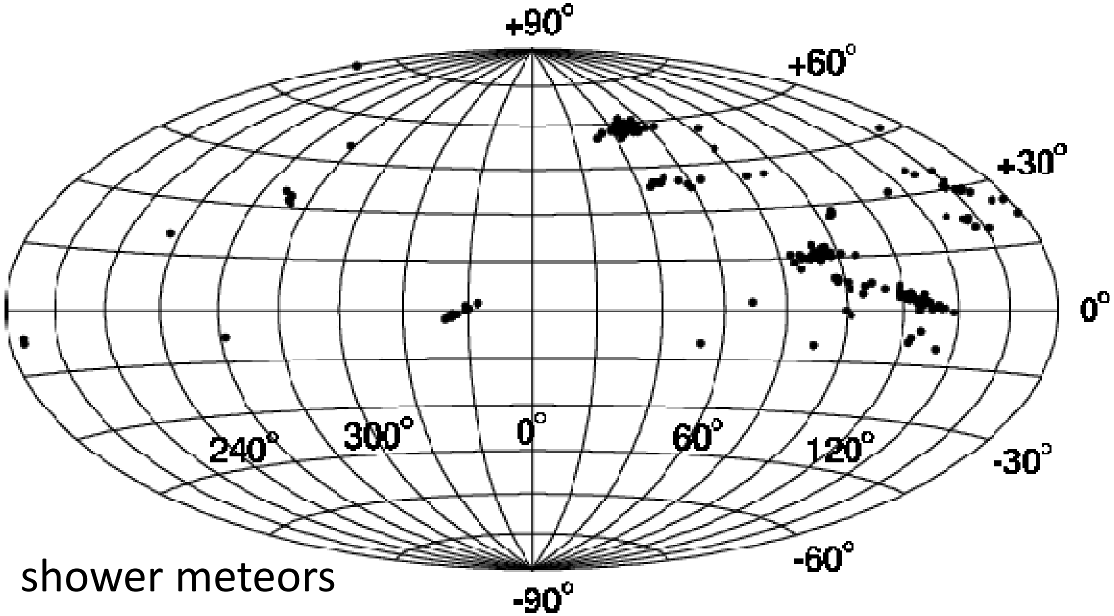


IAU MDC Radar data



The positions of radiants of all hyperbolic meteors with $e > 1$ and $a < 0$ from the meteor data of the IAU MDC. The concentration around the radiants of meteor showers is evident.

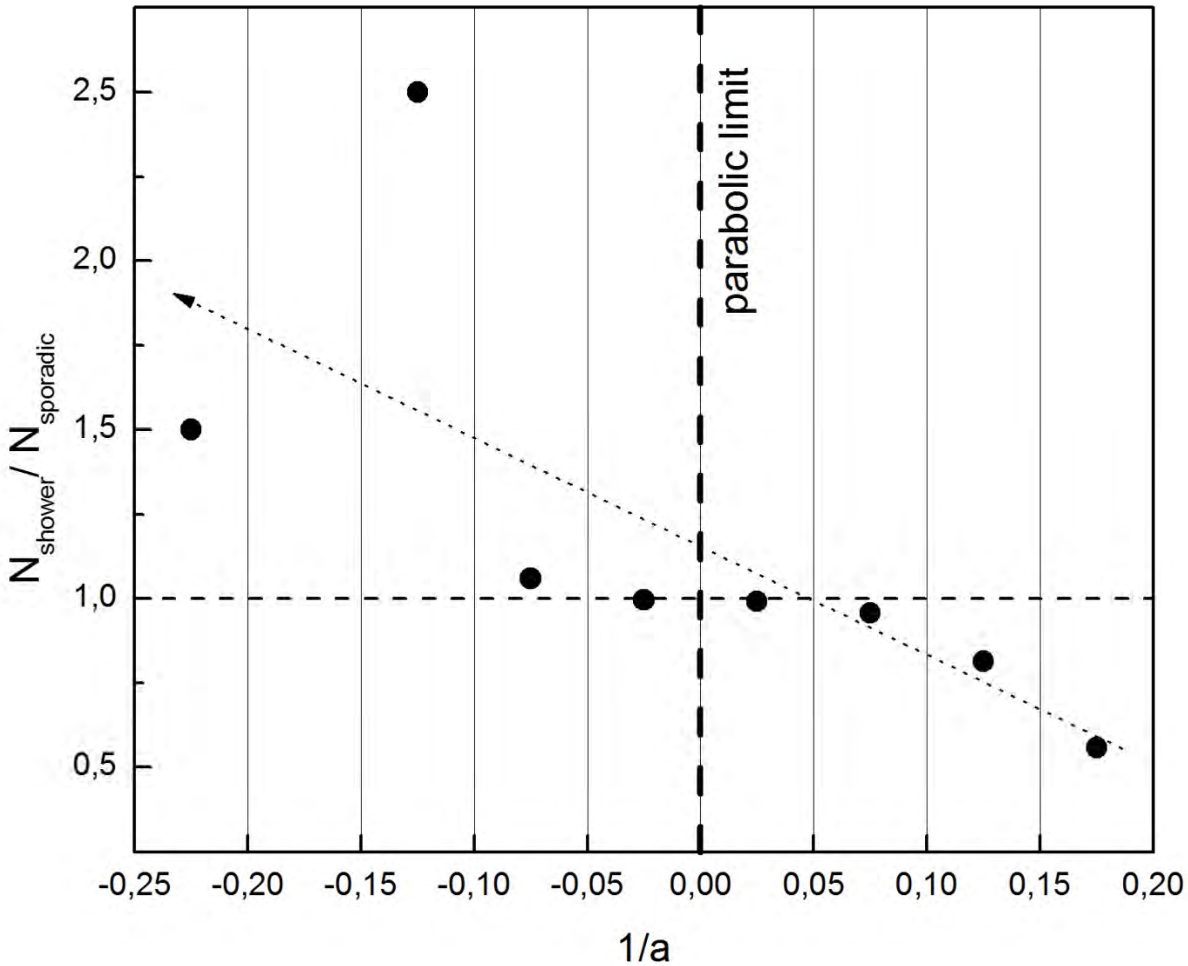




SonotaCo TV catalogue

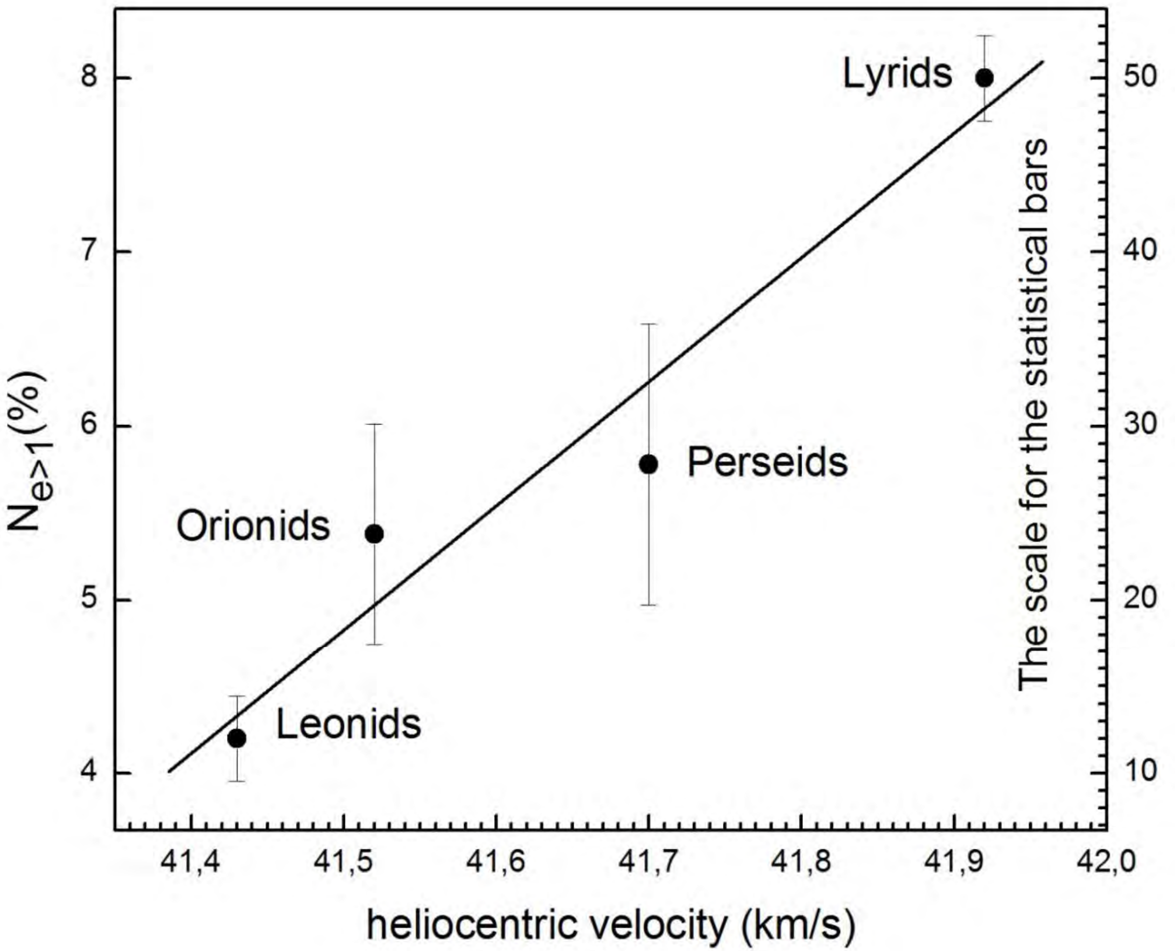
The positions of radiants (in right ascension and declination) of all 484 meteor orbits with e > 1 and a < 0.

The proportion of shower meteors with hyperbolic excesses among all hyperbolic orbits in the database exceeds 1:1.



TV catalogue

The number of shower meteors among the orbits of highest hyperbolic excesses exceeds the proportion 1:1 and is clear evidence of errors.



A dependence of the contribution of hyperbolic meteors in meteor showers on the mean heliocentric velocity of a particular shower $N_{e>1}/N = f(v_H)$ was found. This shows that hyperbolic orbits among shower data are the consequence of error distribution in the velocity.

Observation technique	Photographic		Video	Radar
Limiting mass of meteoroids (kg)	$>10^{-4}$		$> 10^{-5}$	$> 7 \times 10^{-8}$
Source	IAU MDC, phot. Lindblad 1987	IAU MDC, phot. Lindblad et al. 2003	TV catalogue SonotaCo 2009 Quality selection (Veres and Toth 2010)	IAU MDC, radar Lindblad 2003 Quality selection (Harvard catalogues)
$\mathbf{N_{all}}$	2 910	4 581	14 763	39 145
$\mathbf{N_{e>1}}$	347	527	484	970
$\mathbf{N_{vH>46}}$		59	0	258
$\mathbf{N_{ism}}$	15	28	19	54
$\mathbf{N_{ism}/N_{all}}$	2×10^{-3}	6.1×10^{-3}	$< 1.3 \times 10^{-3}$	1.4×10^{-3}
$\mathbf{\Phi_{ism}}$ **($m^{-2}s^{-1}$)**	8×10^{-18}	7×10^{-19}	$< 10^{-16}$	6×10^{-14}
$\mathbf{N_{ism}/N_{e>1}}$	0.017	0.053	< 0.039	0.052

SUMMARY

Diverse realities which produce an unreal hyperbolic population and argue against the occurence of interstellar meteoroids among registered meteor orbits in the catalogues investigated:

- a high concentration of shower meteors among the hyperbolic orbits
- an increase in the proportion of shower meteors with decreasing values of 1/a close to the parabolic limit and beyond
- a dependence of the contribution of hyperbolic meteors in meteor showers on the mean heliocentric velocity of a particular shower
- a dependence of the proportion of hyperbolic orbits in the data on the quality of observations and accuracy of measurements
- the hyperbolic meteors did not show any similar orbital characteristics which follow the motion of interstellar material
- a concentration of their radiants to the Sun's apex was not observed

CONCLUSIONS

- our analysis has called the occurrence of interstellar meteoroids in the vicinity of the Earth into question, at least in the range of large meteoroid particles corresponding to the detection techniques used.

- 96% to 98% of meteoroids with orbits determined as hyperbolic definitely belong to the solar system meteoroid population. About 50 % of them are shower meteors and the other half should be assigned to the interplanetary sporadic background.