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A survey of hydrogen emission in meteors

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Content

- motivation and aim of our work
- topic overview
- processing methods: used softwares
- results: H emission in meteors
- next work - laboratory ablation experiment in plasma wind tunnel

Motivation and aim

- **Motivation**:

➢ H-alpha line - well distinguishable spectral feature indicating the presence of organic matter or water in meteor spectra

- **Aim**:

➢ investigating the presence of organic content in meteoroids by studying the presence and relative intensity of the H-alpha line in meteor spectra (relation to orbital, atmospheric and structural parameters)

Topic overview

- meteors observed by the AMOS network (Slovak stations+ Canary +Hawaii Islands)
- sample: meteors with absolute magnitude in range -1 to -13 (mm-dm):

➢ 270 meteor spectra (2013-2019 Spec)+12(Spec-HR)

➢ with H emission: 60 meteor spectra

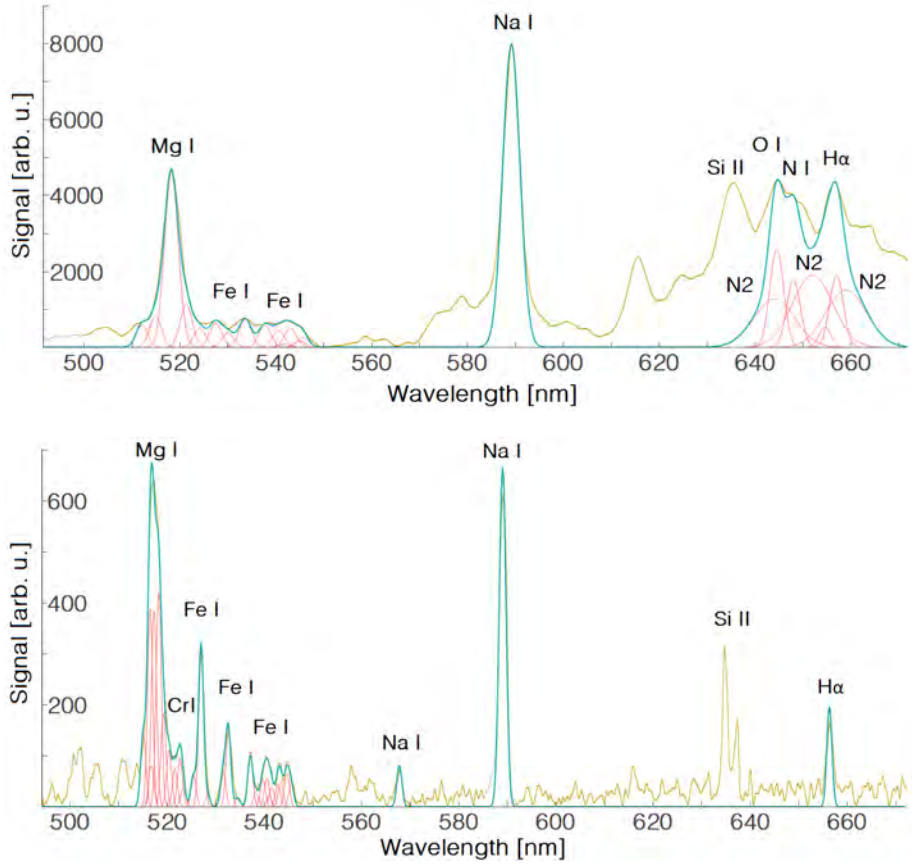
	AMOS-Spec	AMOS-Spec-HR
Camera:	DMK 51AU02	Point-Grey 2048x1536
Lens:	30 mm, f/3.5	6 mm, f/3.5
Grating:	1000 grooves/mm	1000 grooves/mm
Resolution:	1.3 nm/px	0.5 nm/px
FOV:	100 deg	60 x 45 deg
Lim. mag. :	+4.0 / -2	+6.0 / -1.5

Technical parameters of spectral cameras.

Meteor M20180216_193551 captured along with the spectrum by the AMOS-Spec station in AGO Modra.

Data processing

- video recording: UFOCapture
- detection and localization of meteors and stars: AMOS software
- astrometry, atmospheric trajectory and heliocentric orbit: Meteor Trajectory
- spectral reduction and intensity profile: ImageJ
- lines fitting: Fityk

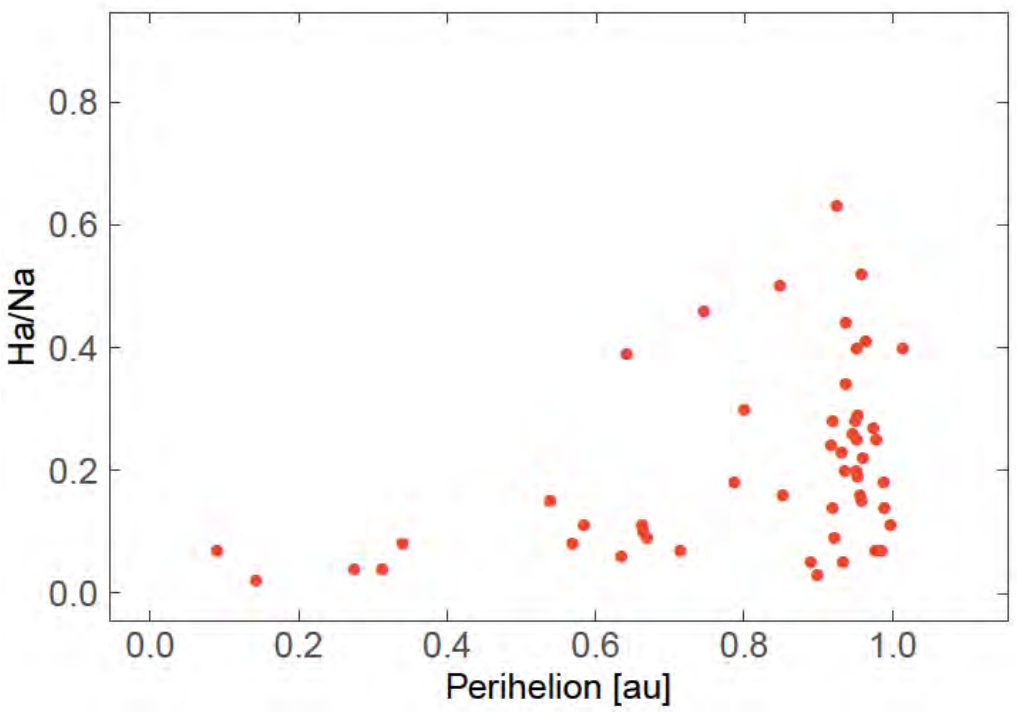


Examples of the fit of the synthetic spectra (blue-green) on measured meteor spectra (yellow) as a convolution of the main emission contributions (red) in the 500-665 nm region (upper panel-Spec, lower Spec-HR).

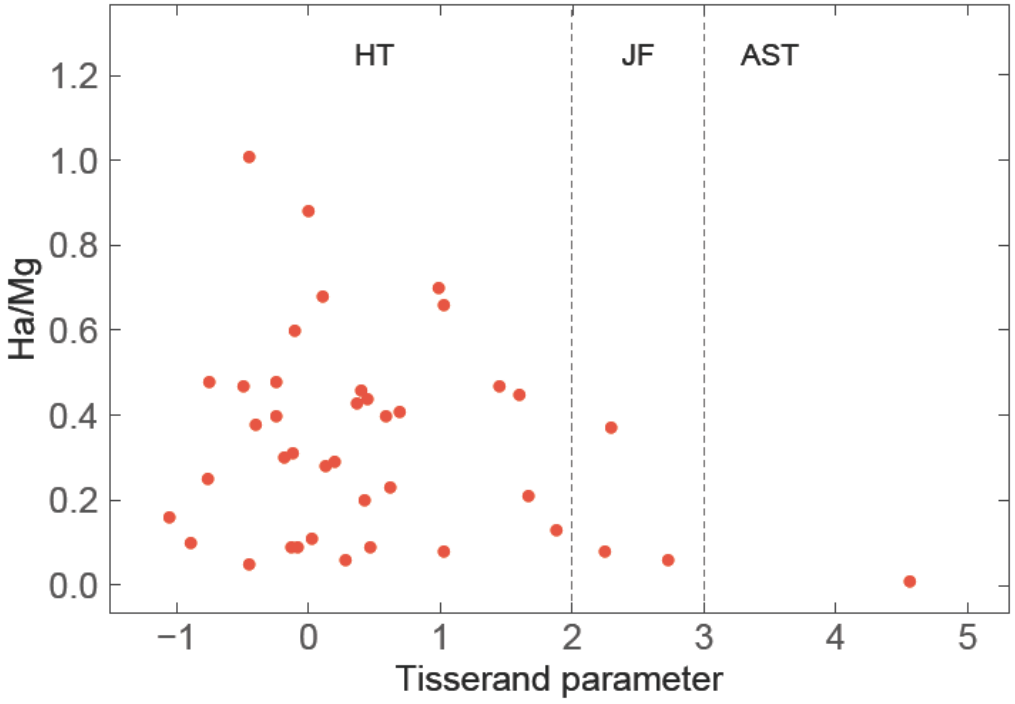
Our strategy for evaluating the presence of H emission

- several works confirmed the detection of H-alpha line emission in the spectra of Perseids, Geminids, Leonids, …, but the overall diversity between meteoroids on larger sample from different sources has not been studied yet
- statistical evaluation:
  - in which meteors the H-alpha line occurs
  - dependence on the orbital origin
  - dependence on the structure of the material
  - function of ablation conditions
  - variation in a particular meteor shower (Perseids) - the same parent body

Results: volatile character of H

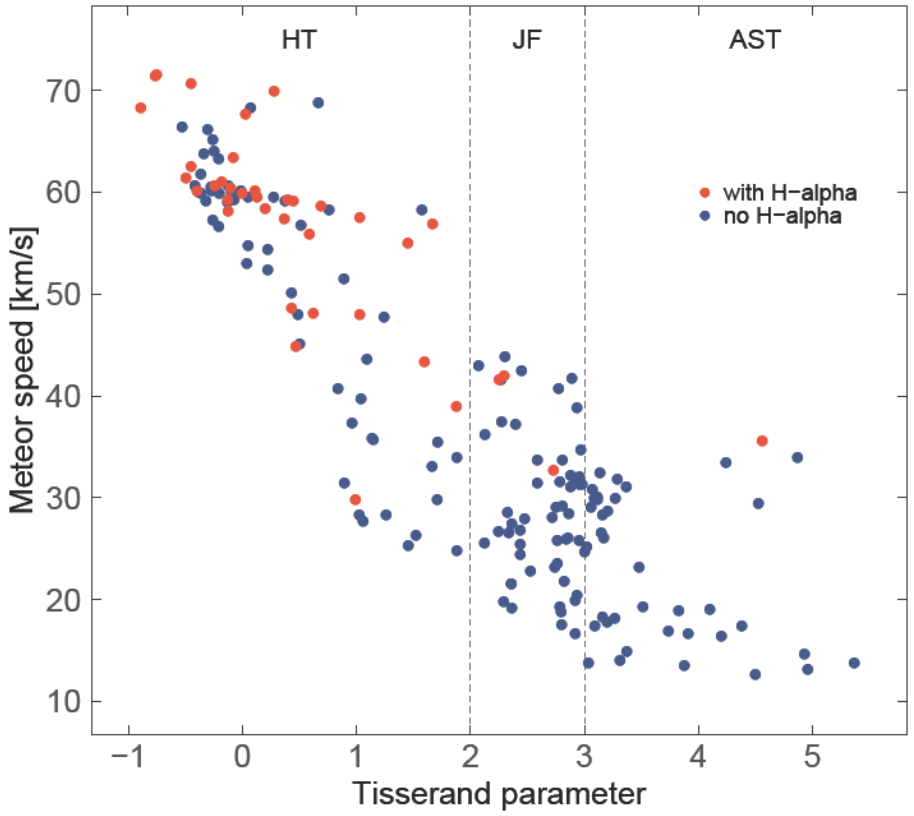


The observed Hα/Na intensity ratio as a function of perihelion distance for meteors with H-alpha line.

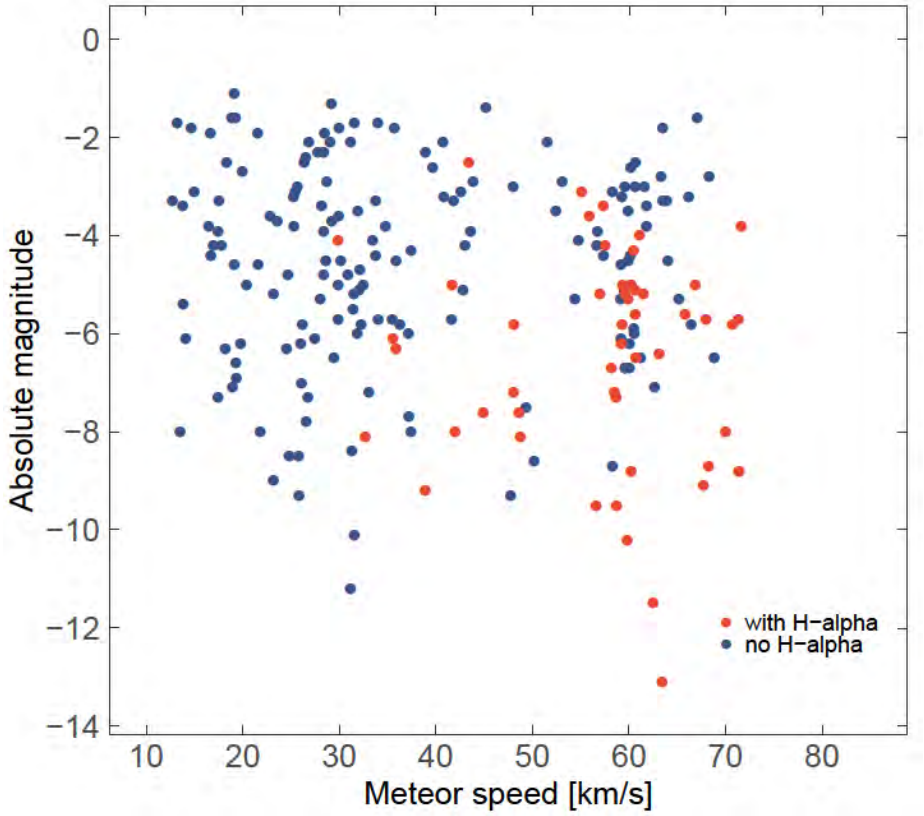


The observed Hα/Mg intensity ratio as a function of Tisserand parameter for meteors with H-alpha line.

Results: Meteor spectra with and with no H-alpha line

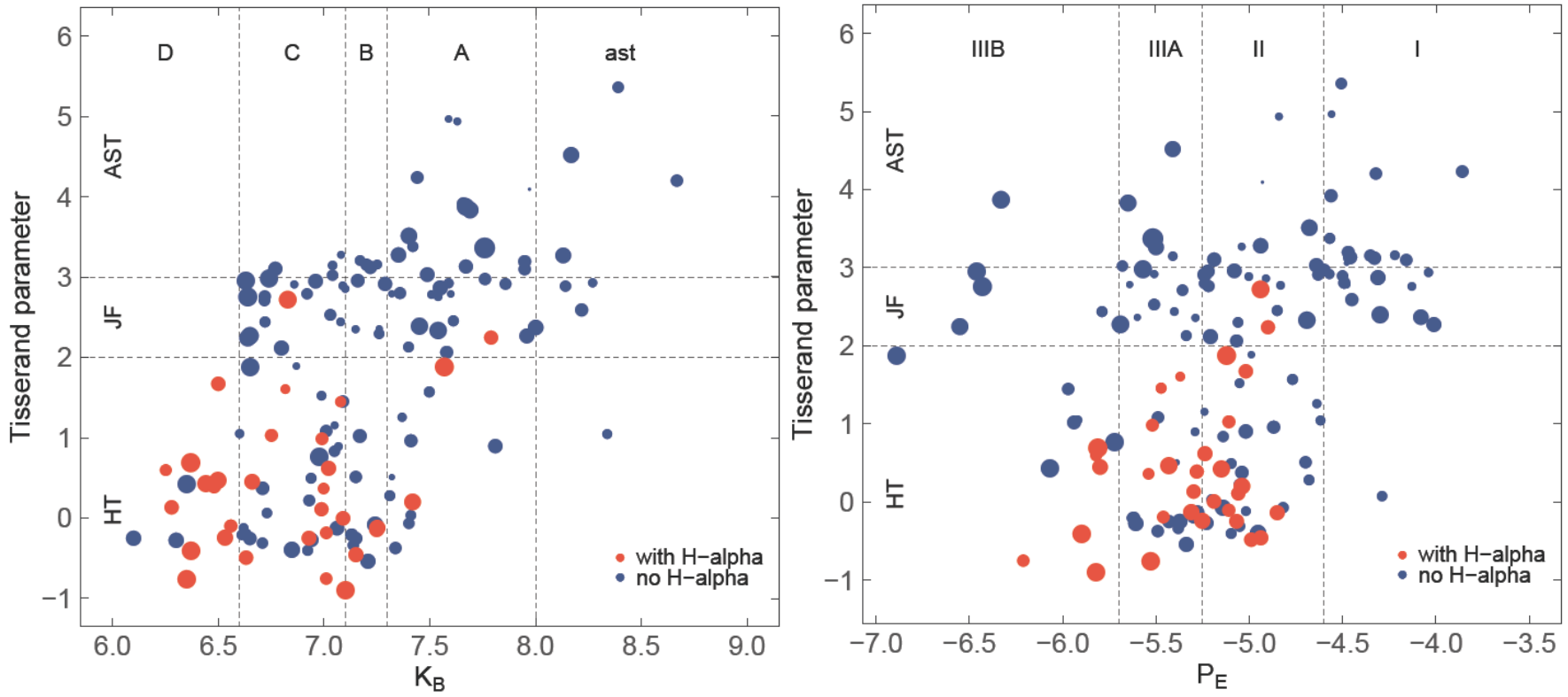


The observed meteor speed as a function of Tisserand parameter.



Meteor speed vs absolute magnitude.

Results: Material strength classification

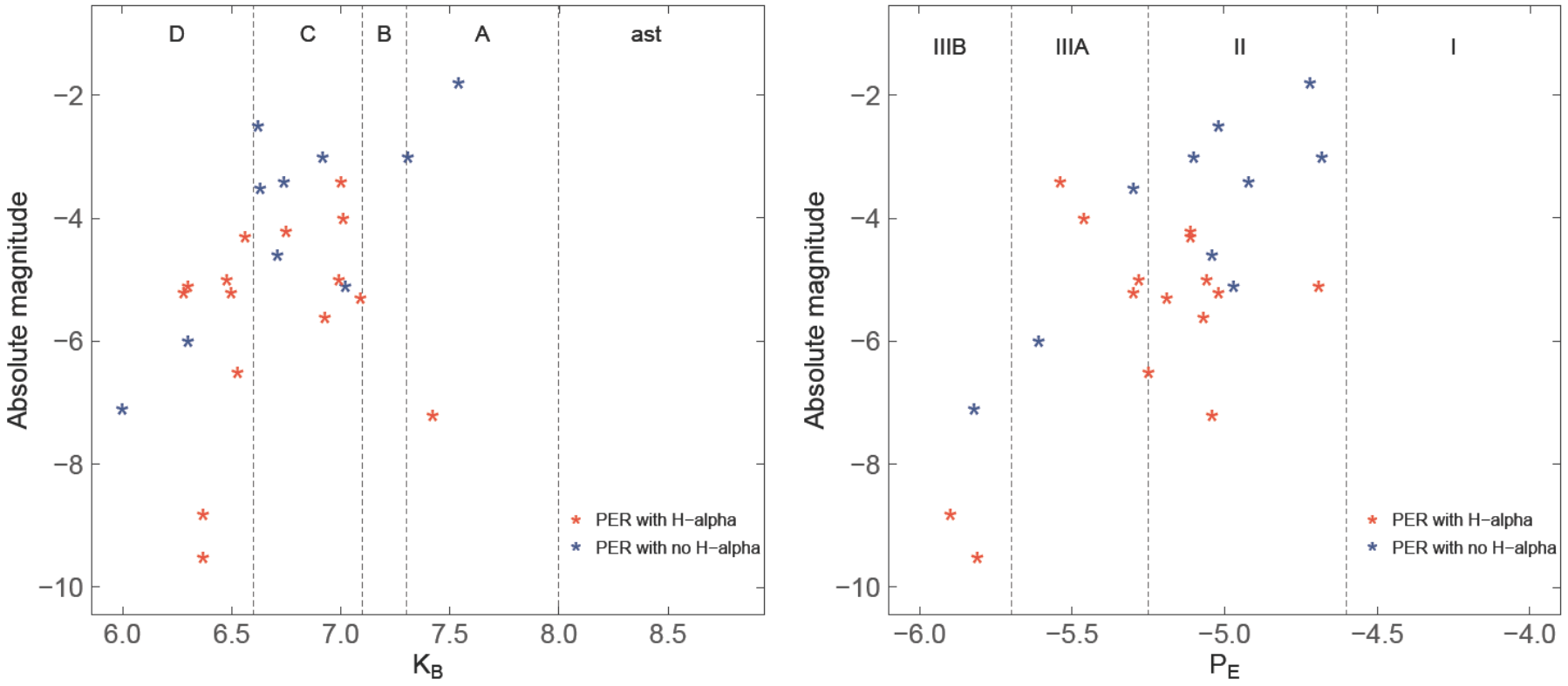


Material strength classification of all meteoroids observed by multiple stations based on the KB (left) and PE (right) parameter as a function of the Tisserand parameter. Sizes of meteoroid marks reflect meteor absolute magnitudes.

Material	K_B	P_E
Fragile cometary	D	IIIB
Regular cometary long-period	C_3	-
Regular cometary long-period	C_2	IIIAi
Regular cometary short-period	C_1	IIIA
Dense cometary	B	-
Carbonaceous chondrites	A	II
Ordinary chondrites asteroids	ast	I

Classification of meteoroid material strength based on KB and PE parameters (Ceplecha 1988).

Results: Perseids and the detection of H emission



Material strength classification of Perseids observed by multiple stations based on the KB (left) and PE (right) parameter as a function of the absolute magnitude.

Next work

- to compare the intensity of the H-αlpha line with larger samples of other meteor showers (comparable velocities with Perseids)
- to analyze the occurrence of H emission:
  - in high resolution spectra (AMOS-Spec-HR)
  - in meteorite spectra (ESA PECS - MetSpec project)

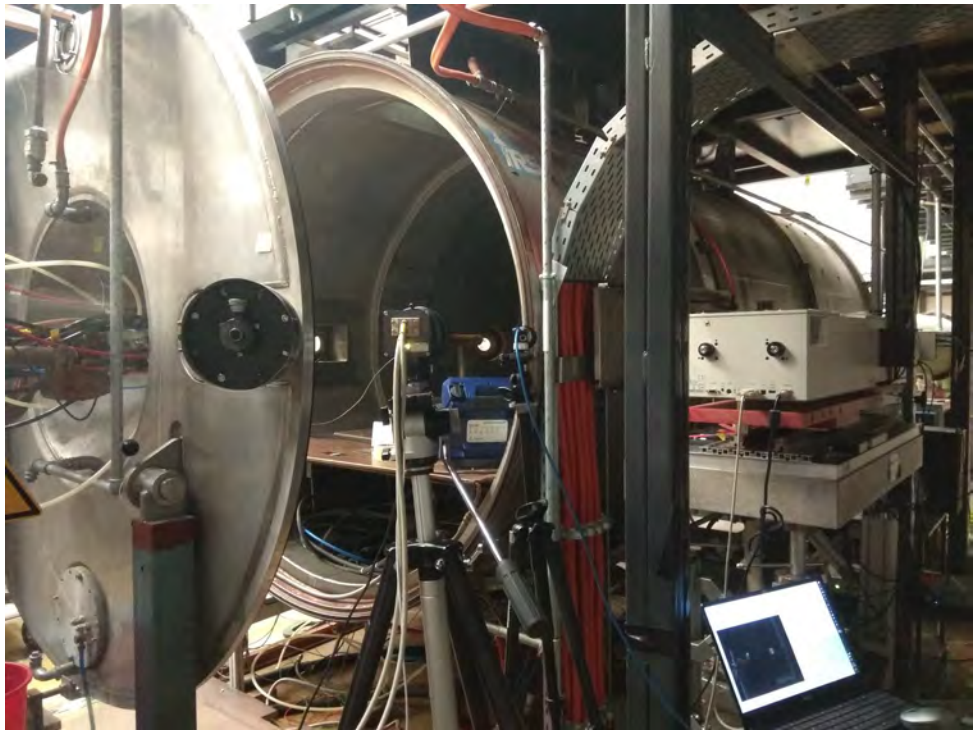
Meteorite ablation experiment campaign

- test conditions corresponding 80 km altitude and 10 km/s speed
- spectra captured by AMOS-Spec-HR and Echelle spectograph

1. campaign	2. campaign
Allende (CV_3) – fall	Northwest Africa 869 (L_{3-6}) – find
Buzzard Coulee (H_4) – fall	Kheneg Ljouâd ($LL_{5/6}$) – fall
Chelyabinsk (LL_5) – fall	Bilanga (Diogenite) – fall
Knyahinya (L/LL_5) – fall	Mount Joy (Iron IIAB) – find
Pultusk (H_5) – fall	Murchison (CM) – fall
Ragland ($LL_{3.4}$) – find	Dhofar 1575 (Ureilite) – find
	Sariçiçek (Howardite) – fall
	Stannern (Eucrite) – fall
	Norton County (Aubrite) – fall

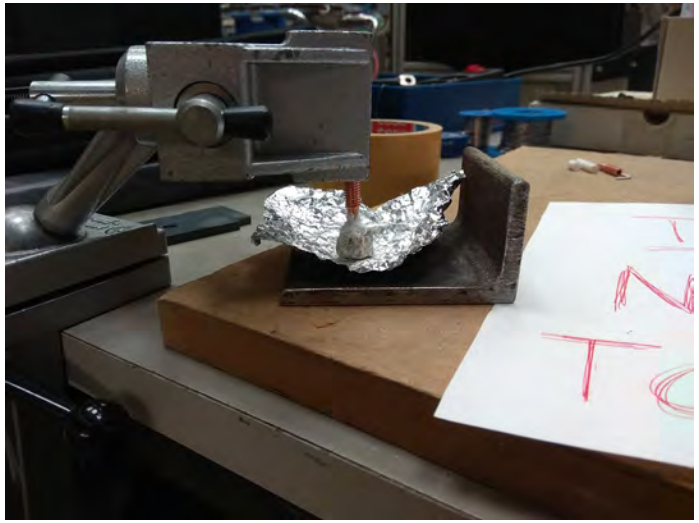
List of testing sample meteorites.

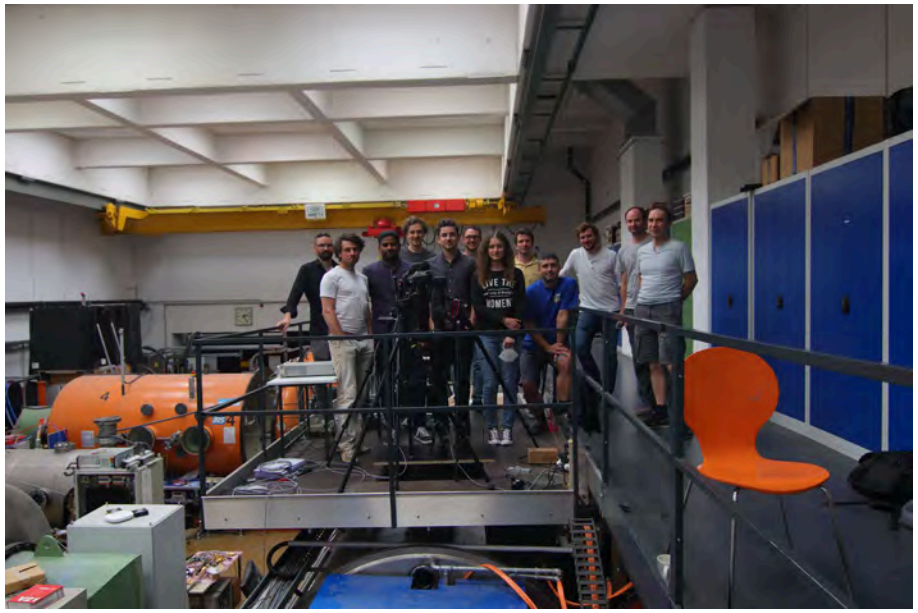
Meteorite ablation experiment campaign



Test preparation photos from the 2. testing campaign.

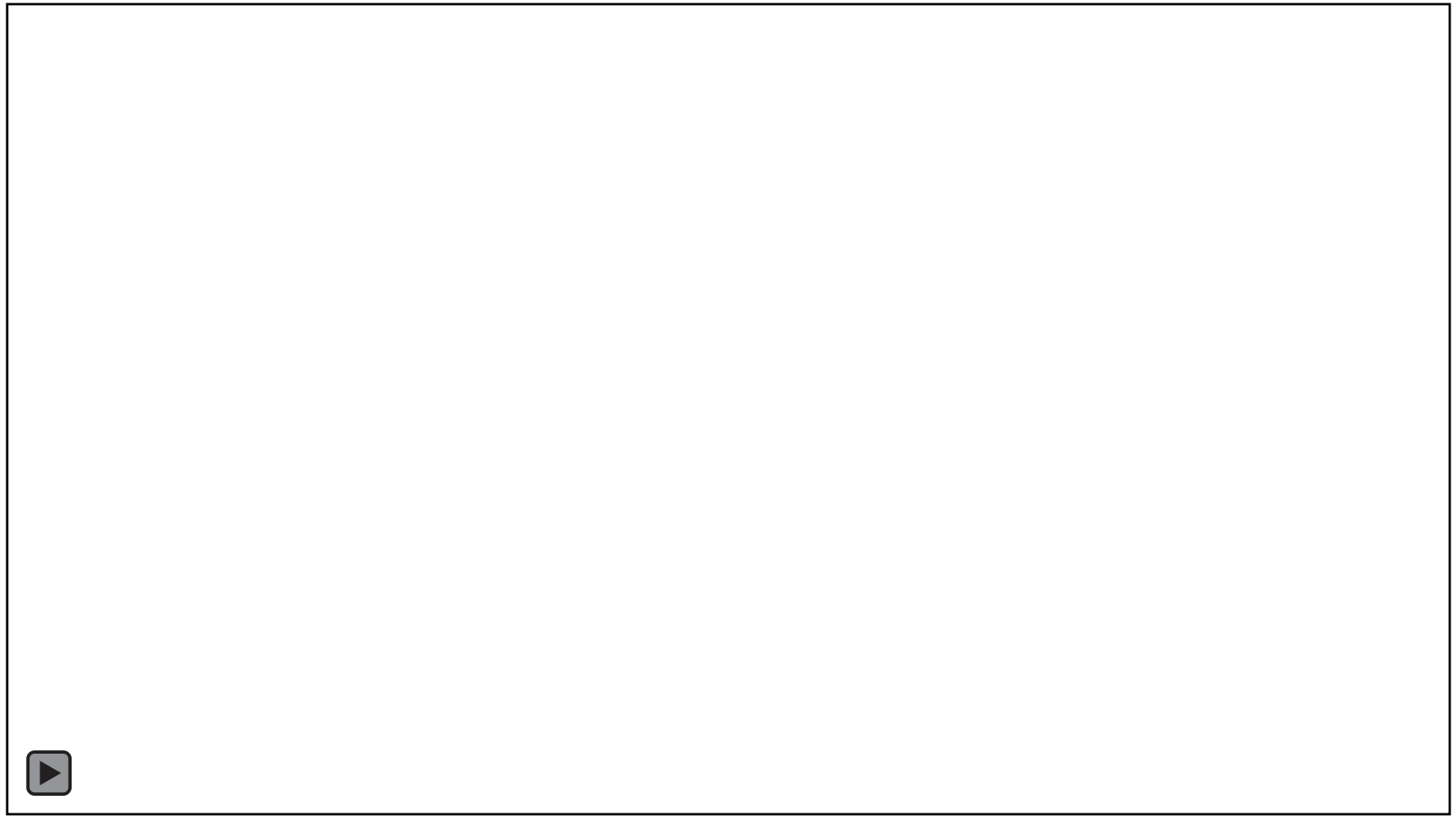
Meteorite ablation experiment campaign





Test preparation photos from the 2. testing campaign (author: J. Vaubaillon).

Chelyabinsk meteorite ablation



Meteorite ablation campaign - preliminary results

- **1. campaign:**
  - **H-alpha line-** significant in Ragland
  - **CN emission-** significant in Allende (carbonaceous meteorite) - Echelle

- **2. campaign:**
  - **H-alpha line-** in most spectra before ablation – why?

Summary

- **Hydrogen emission in meteors:**
  - detection of volatile character of hydrogen
  - detection of hydrogren mainly in faster and brighter meteors from cometary showers
  - fragile material strength
  - in Perseids – variation of the hydrogen emission was mainly related to the meteor brightness
- **Hydrogen emission in meteorite spectra:**
  - H-alpha and CN emission

Thank you for your attention.