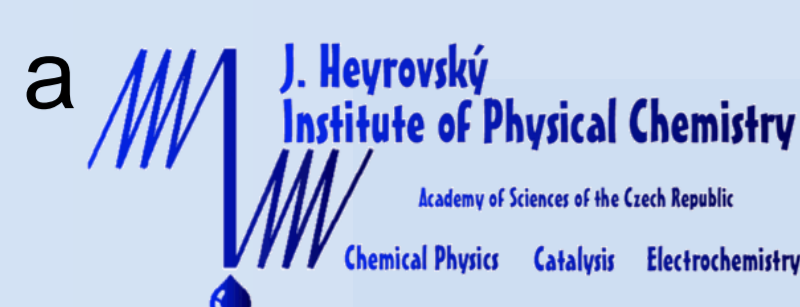


SPECTROSCOPY OF METEORS AND METEORITES ABLATION PLASMA

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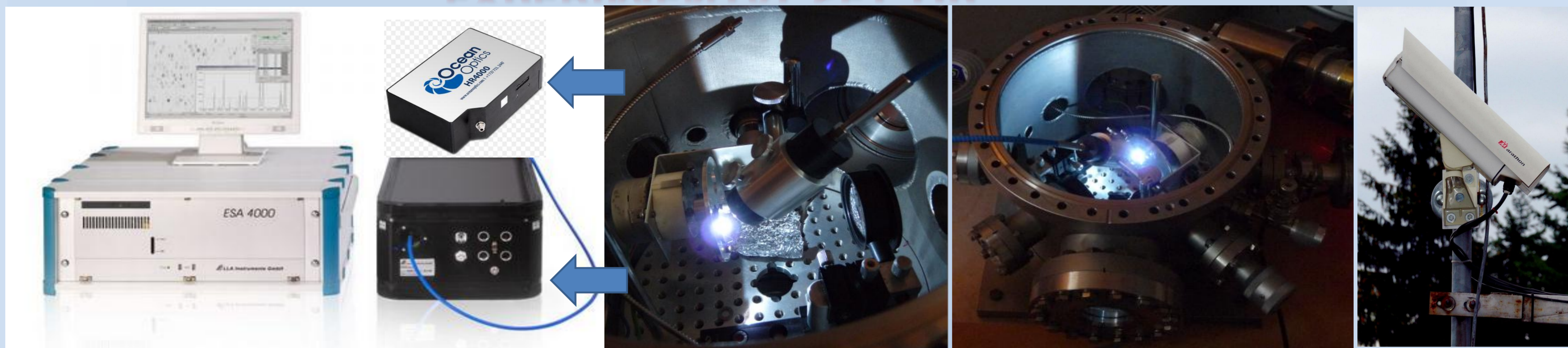


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The chemical composition of distant objects and events in the universe can be determined using only spectroscopic techniques. To understand the observed spectra, laboratory experiments must be performed to compare the spectral features of individual systems under controlled physical and chemical conditions (individual species concentration, temperature, pressure, and electron density). Asteroids are remnants from the materials that first formed the planetesimals and planets, and meteorites are pieces of asteroids on Earth that allow us to measure many of the properties of their parent bodies in detail. However, a fundamental problem exists in linking specific meteorites to their parent bodies (primary matter, asteroids, and comet nuclei). Most meteoroids are also completely desintegrated during the descent through the atmosphere and spectroscopic records remain the only information about their composition. Detailed description and understanding of their spectroscopy and behavior in atmosphere are therefore a challenging scientific problem worth studying. First, our target is a systematization of spectroscopic emission lines for the comparative analysis of meteor spectra. Samples of meteorites have been irradiated using excimer laser. Additionally discharge and LIDB plasma in gas media representing various atmospheres (O₂, N₂, Ar, and CO₂) have also been characterized.

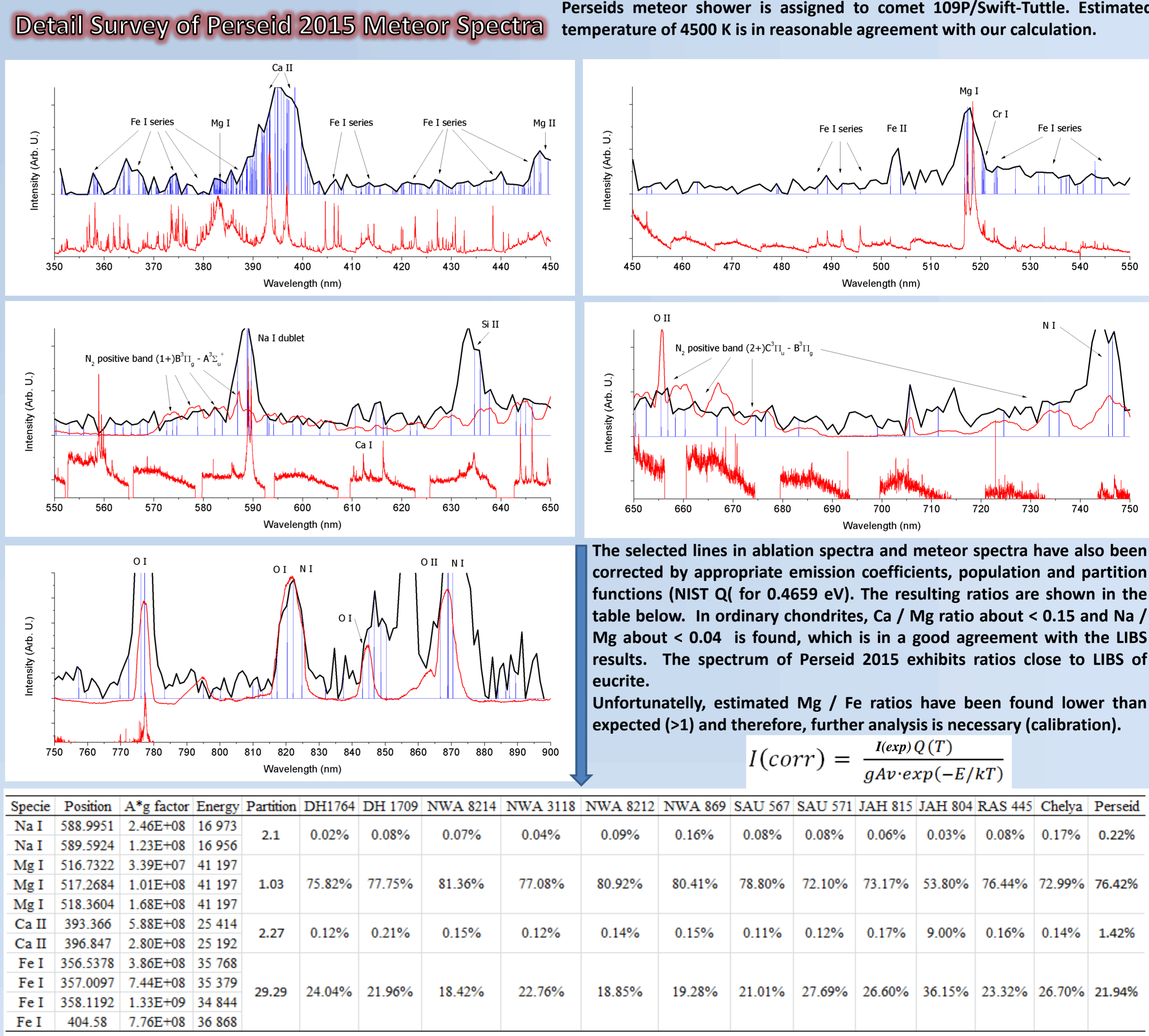
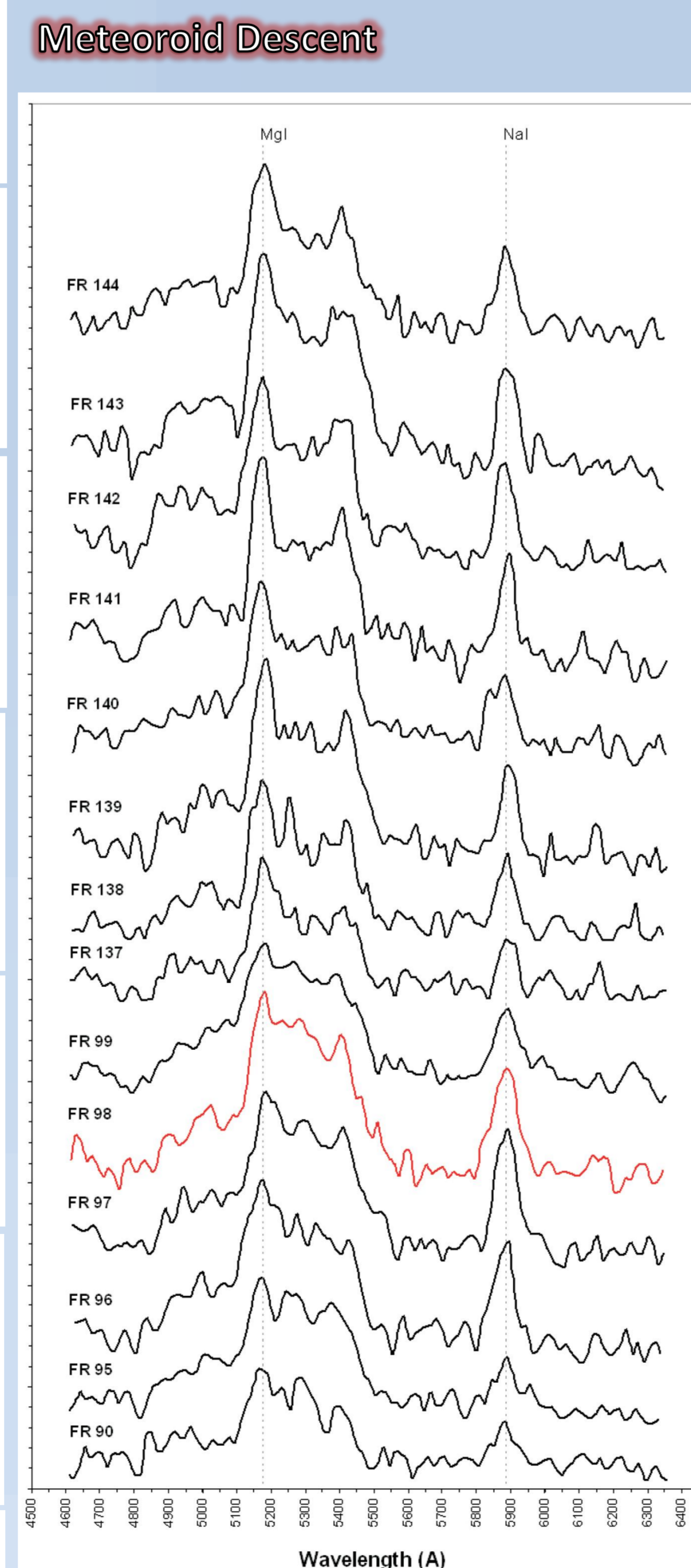
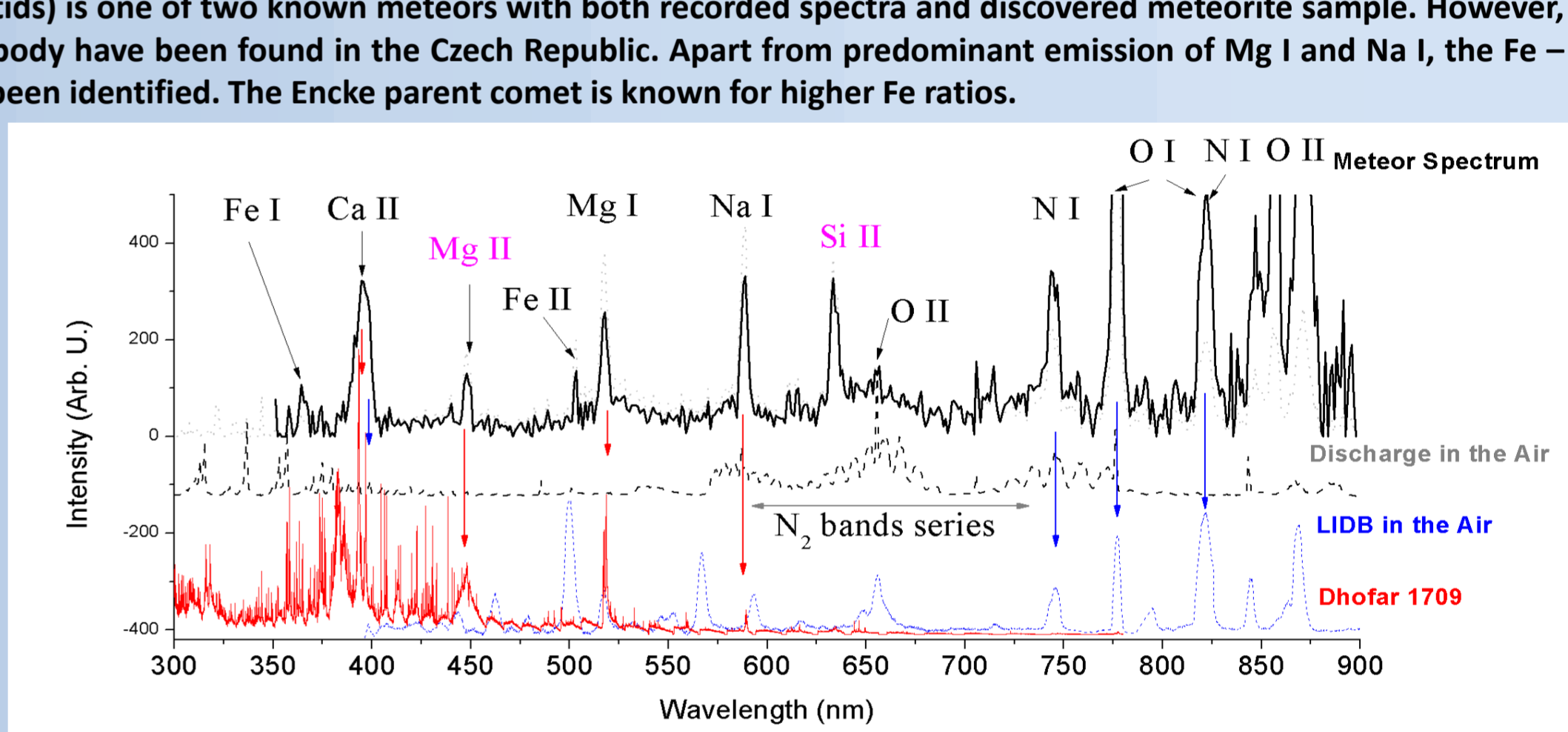
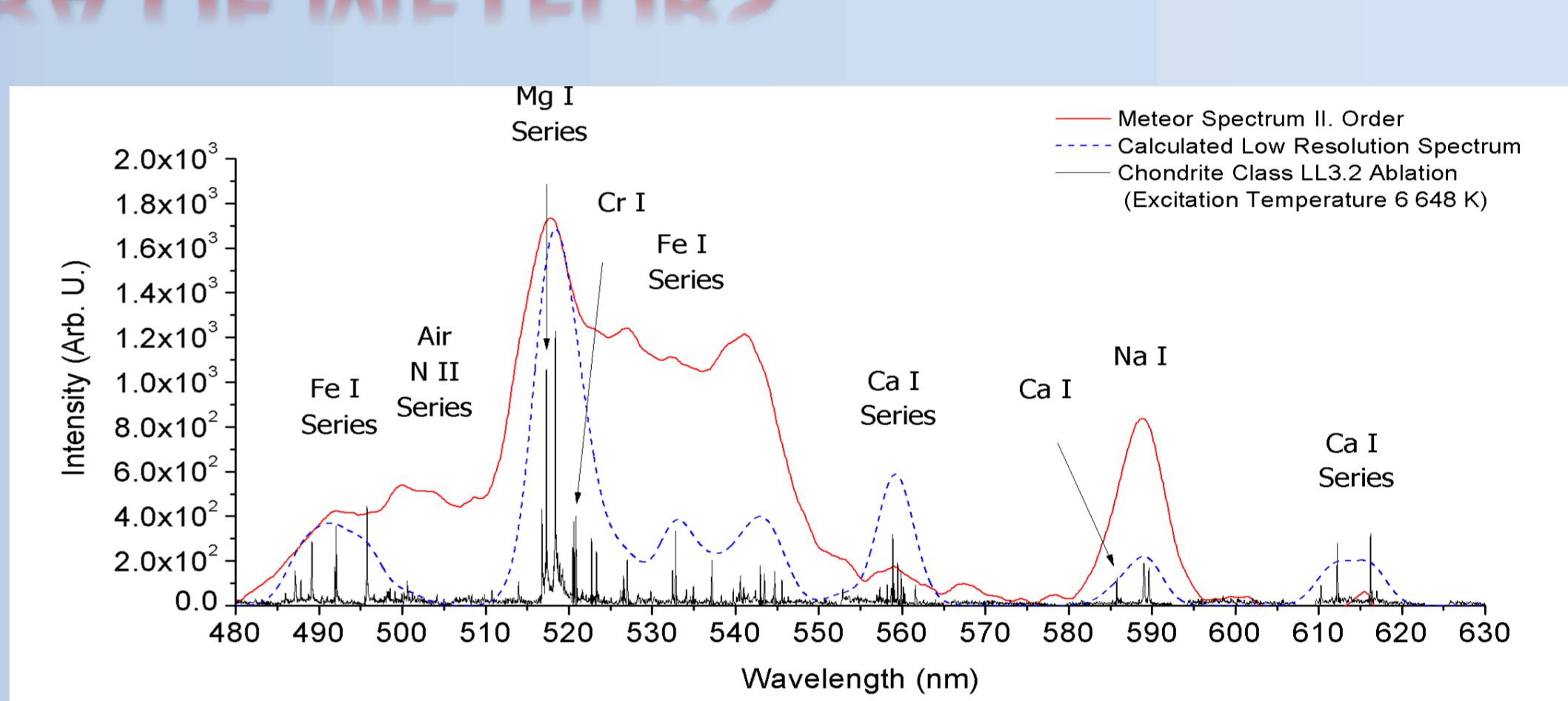
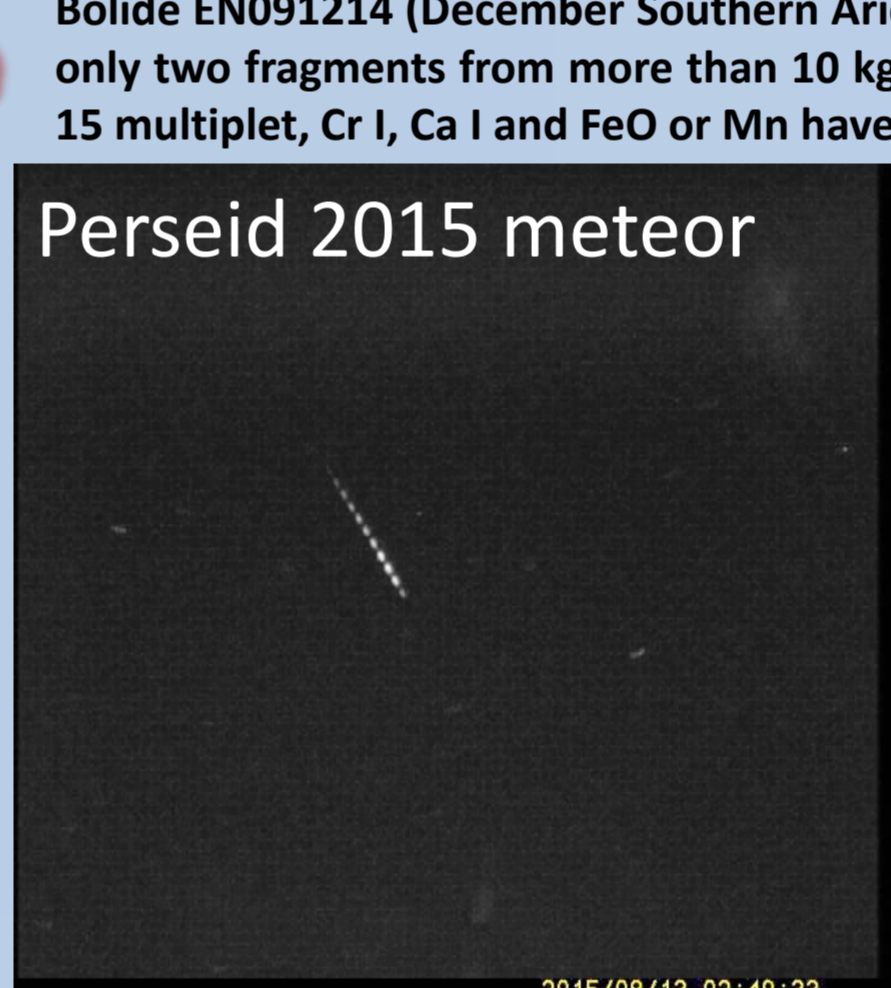
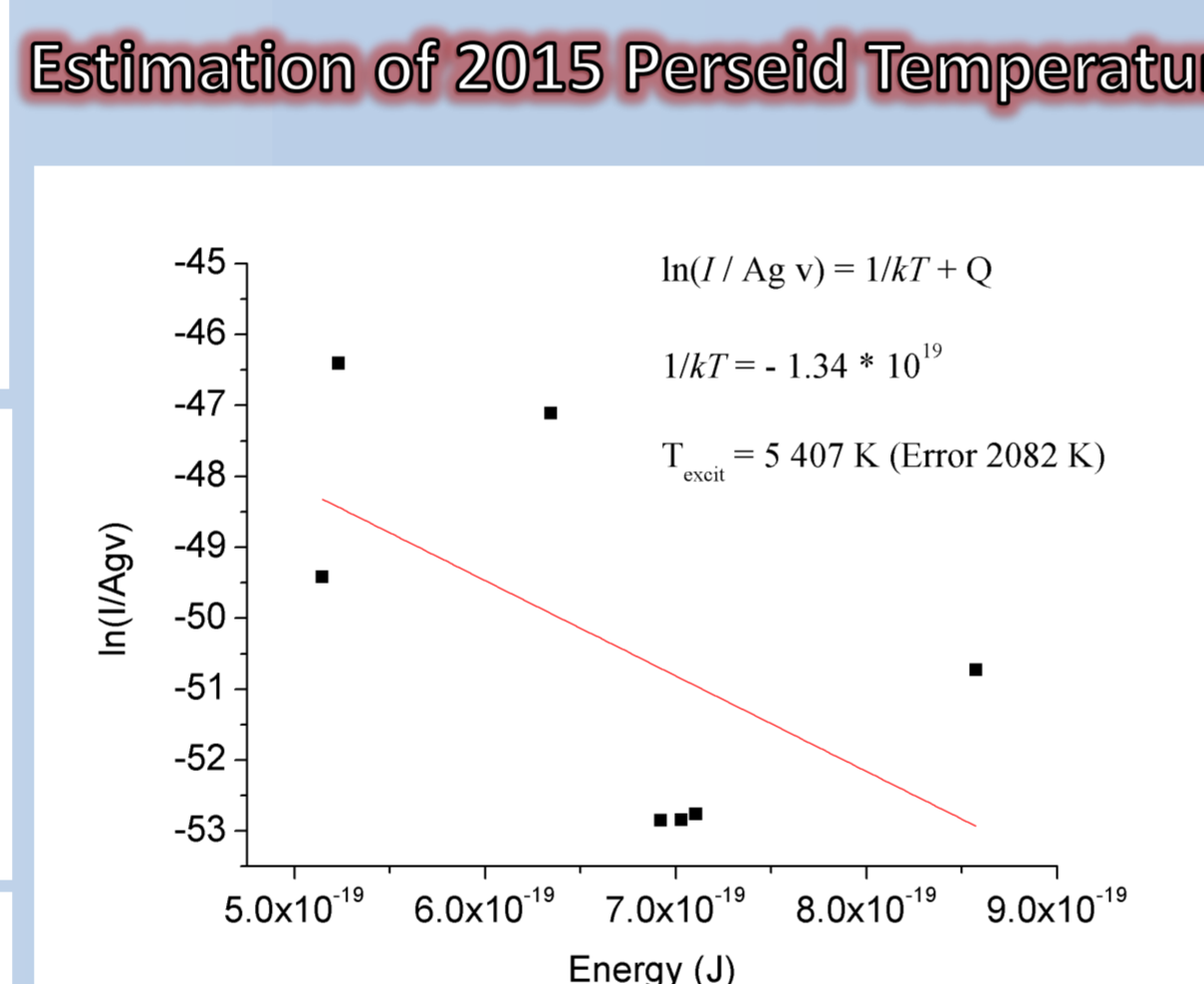
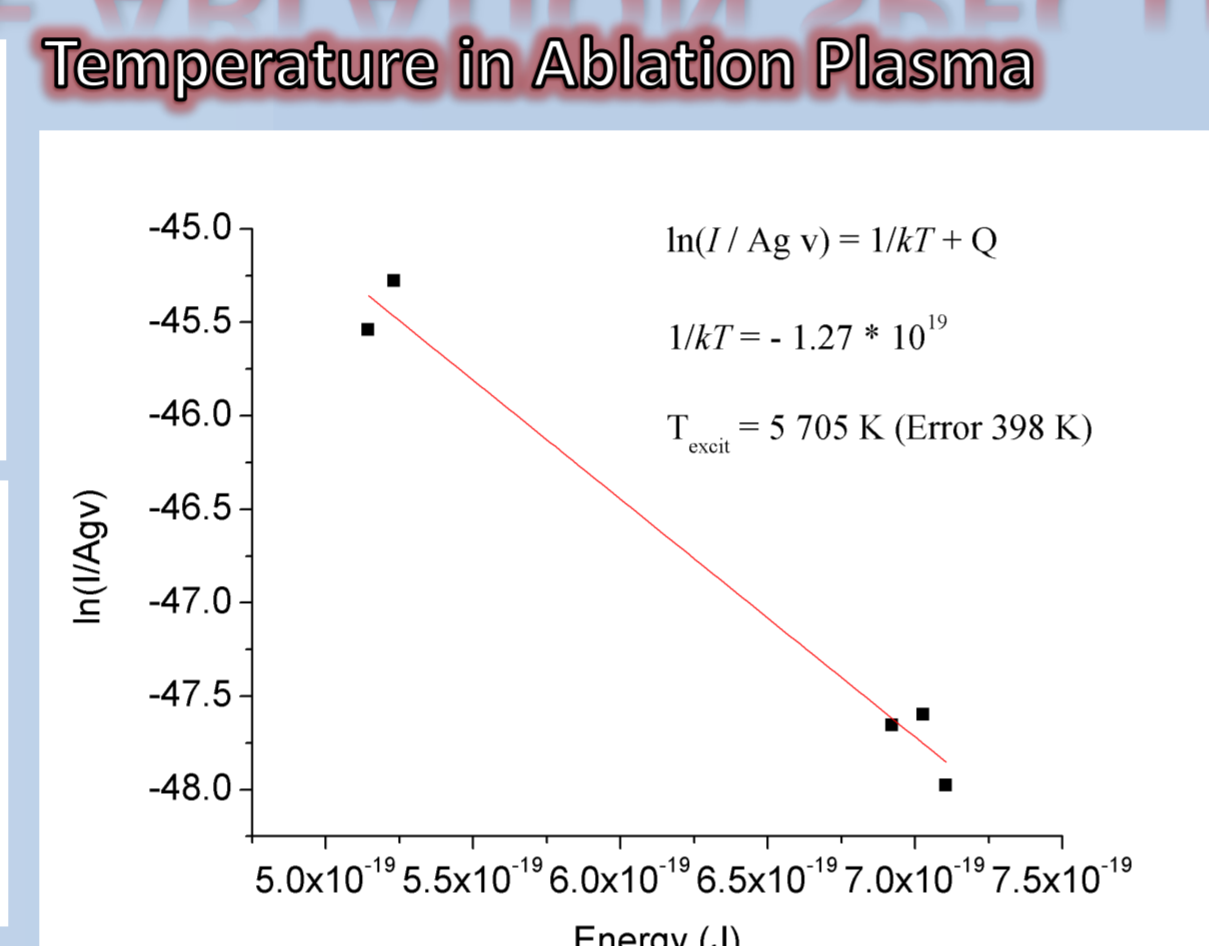
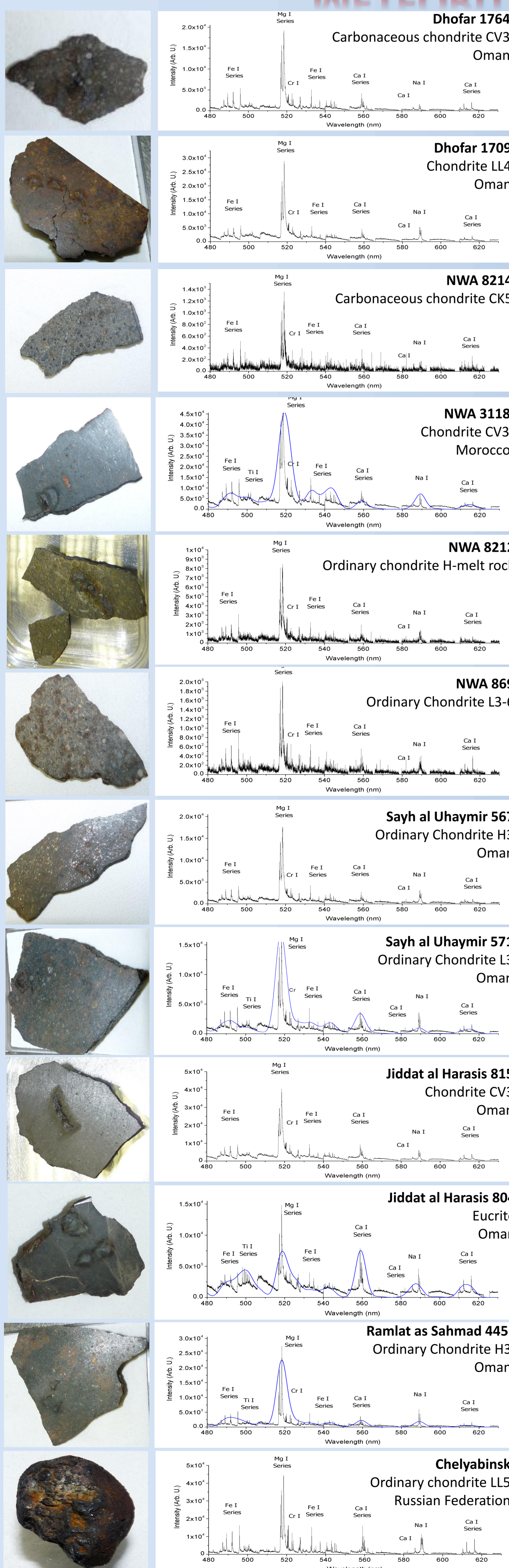
EXPERIMENTAL SET-UP

High Resolution Echelle Spectra Analyzer ESA 4000 (LLA Instruments GmbH, Germany) is a spectrometer system for simultaneous measurement of complex spectra within the entire UV / VIS -range. The optical analyzer unit enables a spatial and temporal resolved image of lowest spectral intensities. The resolution is a few pm in the range 200 – 780 nm
Low Resolution CCD Spectrograph HR4000 (Ocean Optics, USA) provides resolution 0.49 nm in the range 200 – 1100 nm. It is used for comparative measurements.
Lambda Physik Excimer Laser was employed for LIBS ablation of meteorites samples. The comparative spectra of air glow discharge and LIDB plasma have been also measured. The LIDB was generated using Nd:YAG laser.



Meteor spectra are recorded using spectrograph camera equipped with 1/3" CCD chip and holographic diffraction grating. The effective resolution of 720 x 576 px and density 500 lines / mm grating allow resolution of 3.04 nm / px in the range of 585 to 703 nm. The system is calibrated using a neon calibration lamp. The detection itself is performed using UFOAnalyzer software. The cameras on Valašské Meziříčí Observatory are employed in the CEMENT and EDMOND European meteor network.

METEORITE ABLATION SPECTRA AND SPECTRA OF METEORS



The selected lines in ablation spectra and meteor spectra have also been corrected by appropriate emission coefficients, population and partition functions (NIST QI for 0.4659 eV). The resulting ratios are shown in the table below. In ordinary chondrites, Ca / Mg ratio about < 0.15 and Na / Mg about < 0.04 is found, which is in a good agreement with the LIBS results. The spectrum of Perseid 2015 exhibits ratios close to LIBS of eucrite. Unfortunately, estimated Mg / Fe ratios have been found lower than expected (>1) and therefore, further analysis is necessary (calibration).

$$I(\text{corr}) = \frac{I(\text{exp})Q(T)}{gAv \cdot \exp(-E/kT)}$$

Specie	Position	A*g factor	Energy	Partition	DH1764	DH 1709	NWA 8214	NWA 3118	NWA 8212	NWA 869	SAU 567	SAU 571	JAH 815	JAH 804	RAS 445	Chelya	Perseid
Na I	588.9951	2.46E+08	16 973	2.1	0.02%	0.08%	0.07%	0.04%	0.09%	0.16%	0.08%	0.08%	0.06%	0.03%	0.08%	0.17%	0.22%
Na I	589.5924	1.23E+08	16 956														
Mg I	516.7322	3.39E+07	41 197														
Mg I	517.2684	1.01E+08	41 197	1.03	75.82%	77.75%	81.36%	77.08%	80.92%	80.41%	78.80%	72.10%	73.17%	53.80%	76.44%	72.99%	76.42%
Mg I	518.3604	1.68E+08	41 197														
Ca II	393.366	5.88E+08	25 414	2.27	0.12%	0.21%	0.15%	0.12%	0.14%	0.15%	0.11%	0.12%	0.17%	9.00%	0.16%	0.14%	1.42%
Ca II	396.847	2.80E+08	25 192														
Fe I	356.5378	3.86E+08	35 768														
Fe I	357.0097	7.44E+08	35 379		29.29	24.04%	21.96%	18.42%	22.76%	18.85%	19.28%	21.01%	27.69%	26.60%	36.15%	23.32%	21.94%
Fe I	358.1192	1.33E+09	34 844														
Fe I	404.58	7.76E+08	36 868														

CONCLUSION

- Two meteor spectra (Žďár 2014 Bolide and Perseid 2015 Meteor) have been analyzed.
- Several comparative measurements of chondrite ablation plasma spectra have been performed.
- The spectra of meteors are interpreted using experimental data. The lines have been fitted using experimental positions and shapes of emission lines.
- The procedure allows raw estimation of temperature and elements abundances.
- Further very complex analysis and new software must be developed.

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