SHOOTINGSTAR SENSING SATELLITE (S^3: S-CUBE): CUBESAT PROJECT FOR OBSERVATION OF METEORS FROM LOW EARTH ORBIT.

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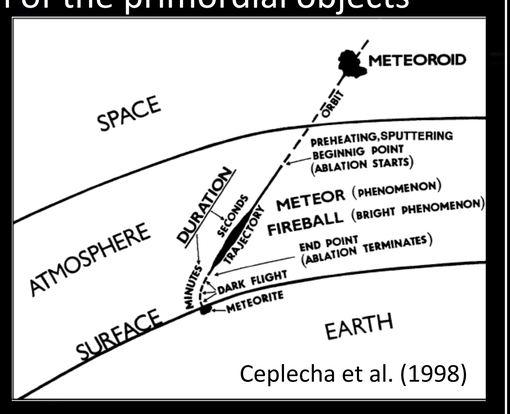
Abstract: Meteors are luminous phenomena induced by hypervelocity entry of meteoroids into the Earth's atmosphere. Because most meteoroids are originated from comets and asteroids, the meteor give us valuable opportunities of an indirect exploration of the primordial objects in the solar system. Although meteors have been observed mainly from the ground, the ground-based observations have observational biases: observatories biased in the northern hemisphere and weather-dependence. In contrast, a space-based observation by an earth-orbiting satellite enables a continuous global observation of meteors. Further, it can detect ultra-violet emission from meteors because it is not hindered by ozone layer. Our new satellite project was started by a partnership between Planetary Exploration Research Center of Chiba Institute of Technology and Tohoku University to develop a 3U CubeSat "S-CUBE". The satellite is equipped with optical sensors, such as a camera and photomultipliers, to take visible images and observe UV emissions of meteors from a low-Earth orbit. We can estimate the meteoroid size from visual brightness of meteors. Detection of UV emission of meteors is used as a trigger of the camera. It is also suggested that UV emission of meteors includes emissions of some light elements, such as carbon and sulfur, which have not been observed by previous ground-based observations. The launch date is planned in the 2014.

Background: Meteor research

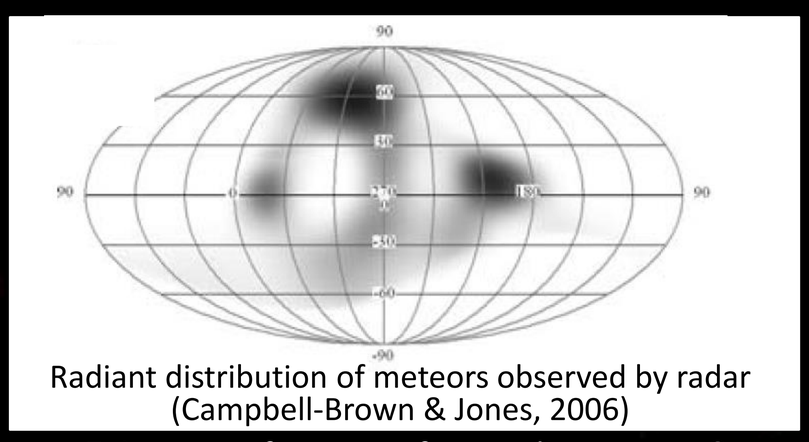
- Most meteors are thought to be originated from comets and asteroids.
- Meteor observation is an indirect exploration of the primordial objects in the solar system.
  - Composition → Origin
  - Size distribution

  → Physical process of parent body / Release processes of meteoroids / Orbital evolution of meteoroids



Ceplecha et al. (1998)

- Meteors have a localized radiant distribution

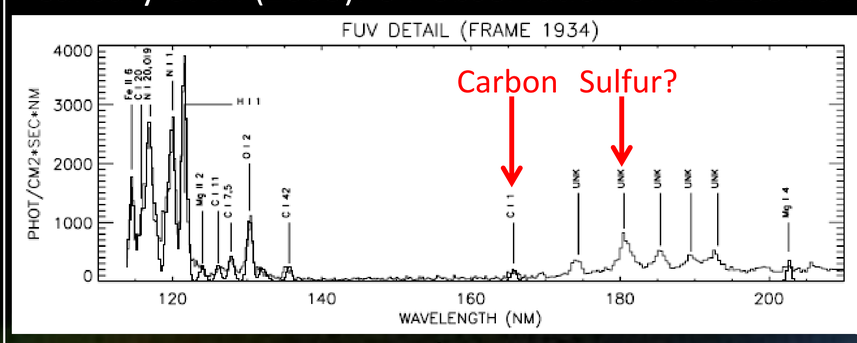


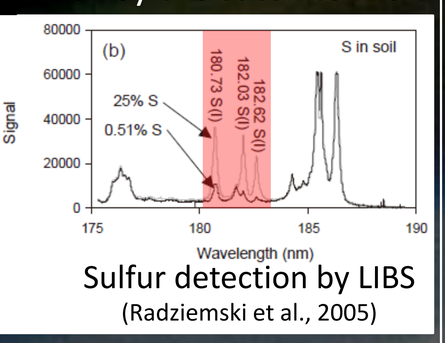
Radiant distribution of meteors observed by radar (Campbell-Brown & Jones, 2006)

Existence of source of sporadic meteors?

- Ultraviolet meteor spectra

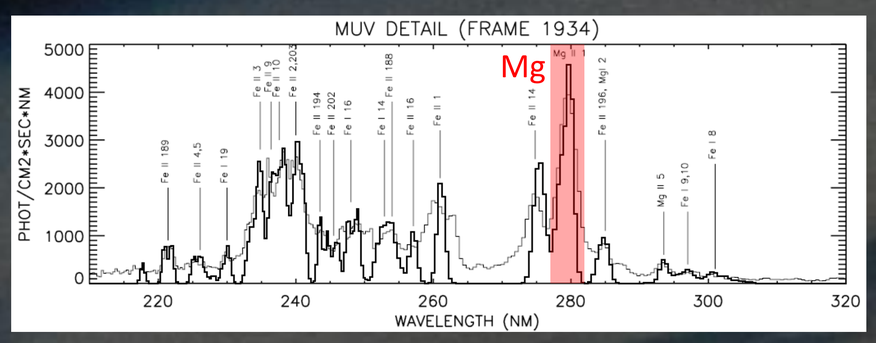
Carbary et al. (2003): UV observation of the Leonid meteor by the satellite MSX





Sulfur detection by LIBS (Radziemski et al., 2005)

FUV region contains information on important species, such as C and S, which are not observed at longer wavelengths.
→ The volatile elements reflect thermal history of meteoroids and their parent bodies



- The strong UV emission arises, in particular, from metals such as Mg.
- Ozone layer blocks UV light from the Earth

→ Detection of UV emission from metals in orbit is regarded as a meteor signal.

- Observational bias (Ground observation vs Space observation)

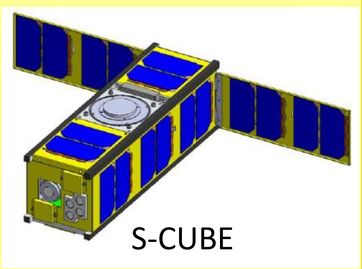
	Observation point	Dependence on the weather	UV observation
Ground-based observation	Biased in the northern hemisphere	Dependence	Hindered by ozone layer
Space-based observation (Satellite)	**Global**	**independence**	**Possible**

Shootingstar Sensing Satellite (S-CUBE) project

Mission

We observe meteors from space by using a CubeSat.

- ✓ **Minimum success**:
  - Detect UV emission from a meteor by PMT
    →Used as a trigger of a camera
  - Take an image of meteor by a camera
    →Estimate the meteoroid size from brightness
- ✓ **Full success**:
  - Obtain the flux (i.e., size distribution) of meteors
- ✓ **Optional**
  - Estimate the compositions of meteors quantitatively from emission from species, such as sulfur

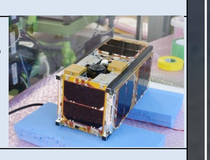
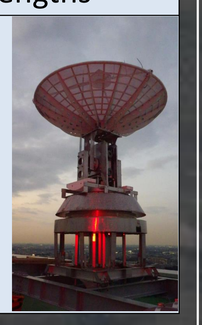

S-CUBE

- CubeSat
  - **Small**: 1U CubeSat is 10cm cube and weighs ~1kg.
  - **Cheap cost**: $100,000 -500,000 (including launch cost)
  - **Speedy development**: 2-3 years
  - Technology demonstration in orbit has been fully done already.

  → **Entering the age of the science CubeSat mission!**

S^3 project aims to accomplish the first CubeSat mission in planetary sciences.

- Specification of S-CUBE
  – Utilize existing technology as much as possible

Size	3U: 30cm × 10cm × 10cm	
Mass	3.99 kg	
Bus system	Developed based on the 2U CubeSat "RAIKO" (# RAIKO in orbit now) 	
Attitude control	3-axes magnetic torquers, Gravity-gradient stabilization by the extension boom	
Communication	Uplink: UHF, Downlink: S-band	
Altitude	500-800 km (TBD)	
Orbit	Sun-synchronized orbit (TBD)	
Life time	1-2 years	
Scientific instrument	**Camera**	- CCD (Watec T065) - Used as instrument of the SPRITE-SAT 
	Photomultiplier tube (PMT)	- Hamamatsu photonics - Detectable at ultraviolet wavelengths
Ground station	Chitech has experience of satellite development and operation. → Ground station is available 	

Schedule	2012		2013				2014	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Instrument	Pre-design		EM Development		EM test		FM Manuf.	Launch (TBD)
Bus system	Pre-design		EM Development		EM test		FM Manuf.	
Ground station	Overhaul & test				Open	Comm. test	Assembly AT	
QL			Pre-design	Development				