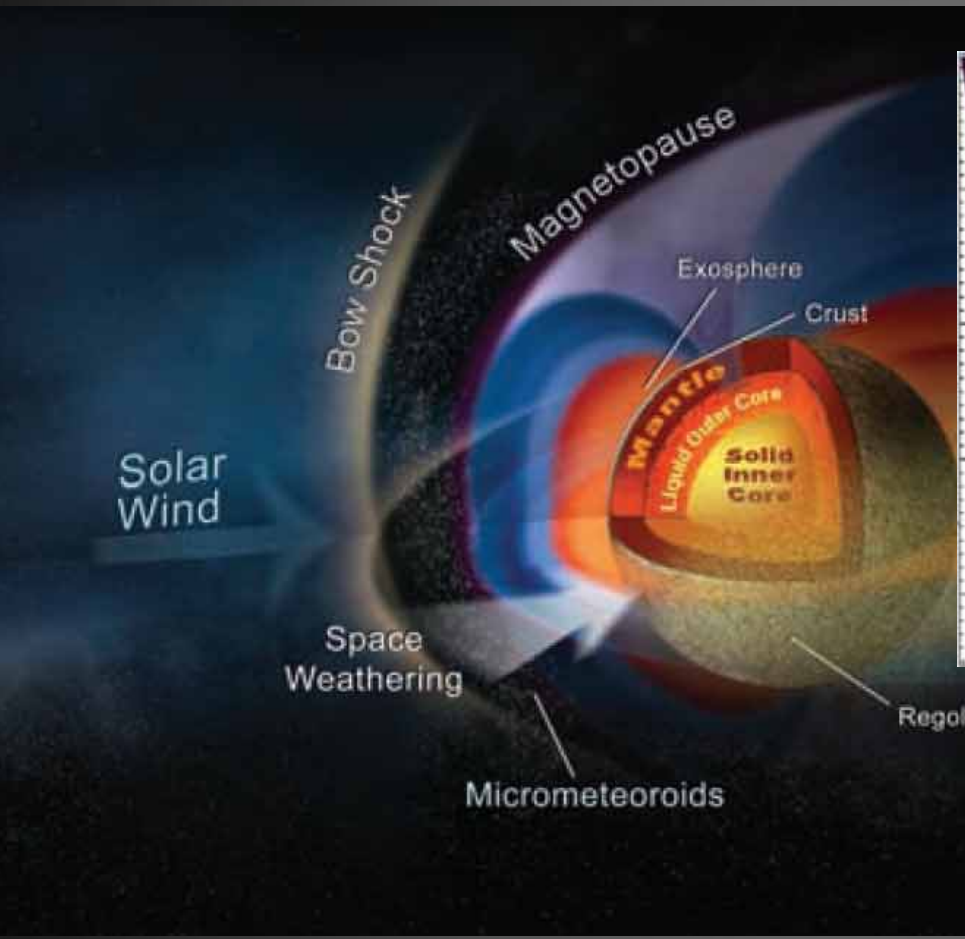
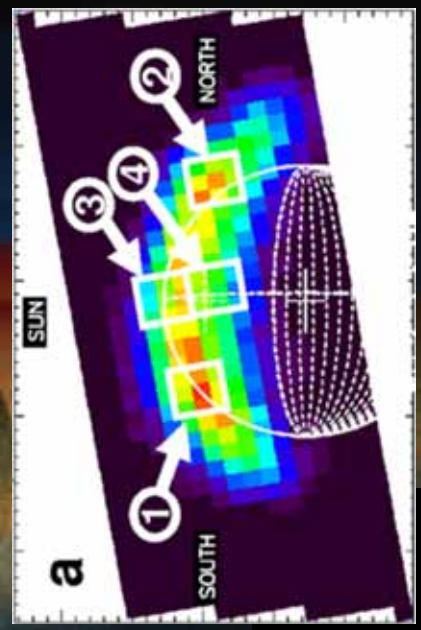
水星ナトリウム大気光分光観測器MSASI

亀田

水星ナトリウム大気生成過程

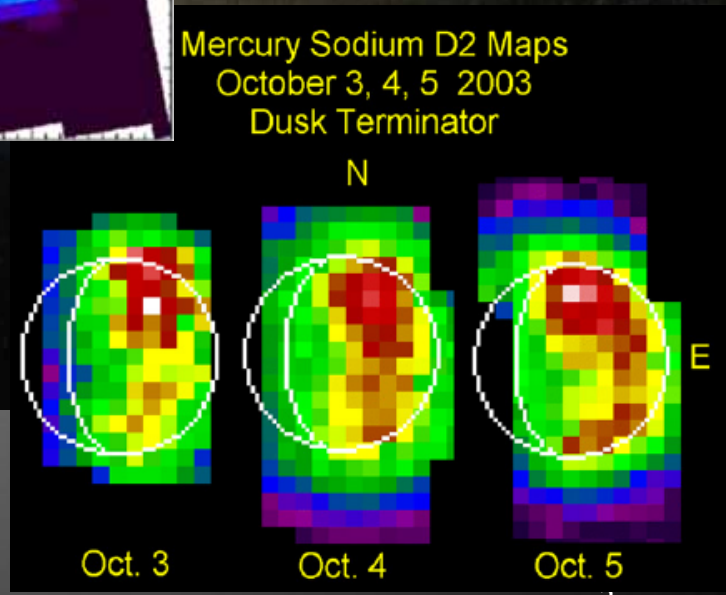


Solomon et al., 2008



Leblanc et al., 2008

Sodium Tail



Potter et al., 2008

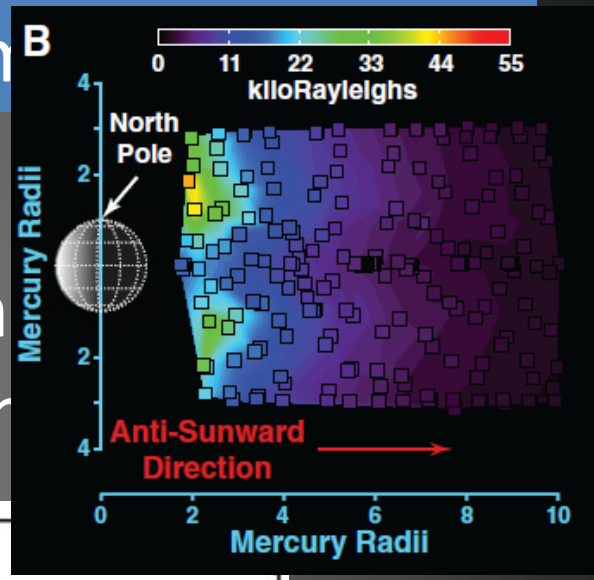
太陽光、太陽風、隕石衝突などで
地表からナトリウムが放出される。
高緯度で高密度→ 太陽風スパッタリング

Scientific C

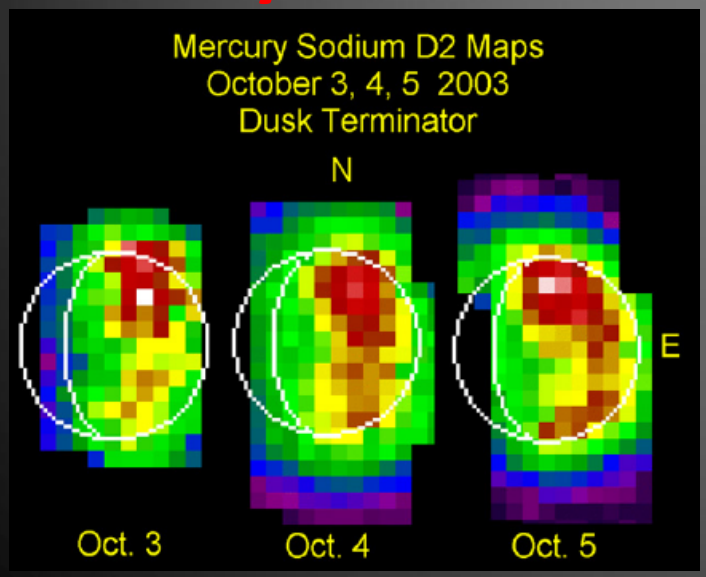
Messengerでは昼側の観測ができない。

Δλ~1nm

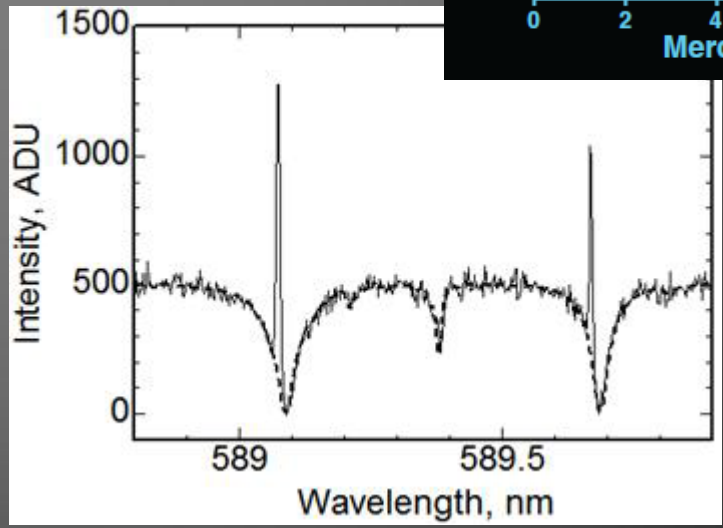
- MSASI is “Mercury Sod Spectral Imager.”
- Spectral resolution of ~85,000 en observe distribution of Na exosph **dayside.**



McClintock et al., 2008



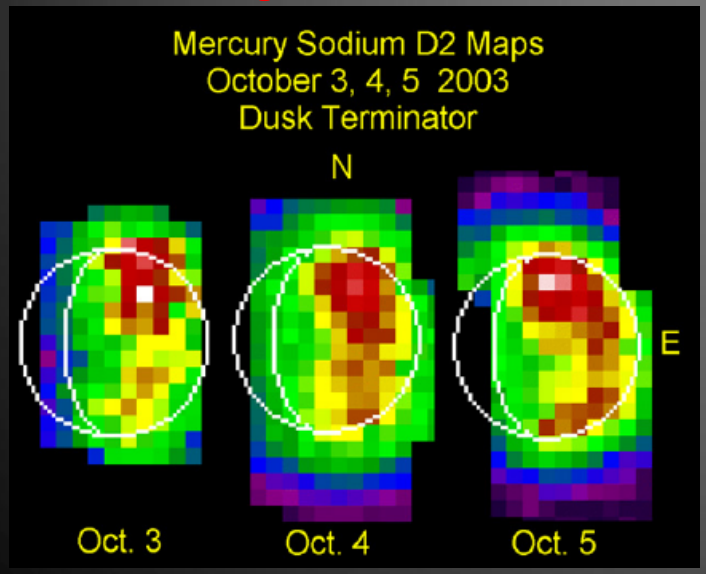
Potter et al., 2008



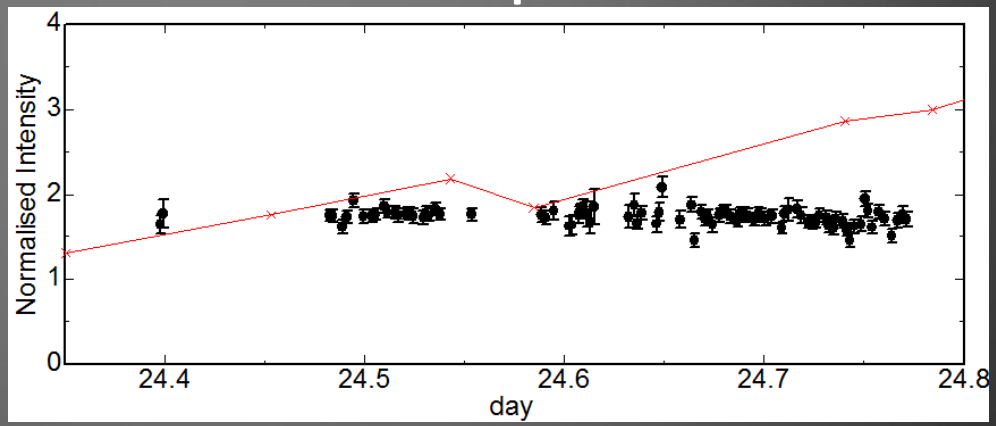
NaD2, D1 輝線幅は5pm

Scientific Objectives

- MSASI is “Mercury Sodium Atmosphere Spectral Imager.”
- Spectral resolution of ~85,000 enables us to observe distribution of Na exosphere on the **dayside.**



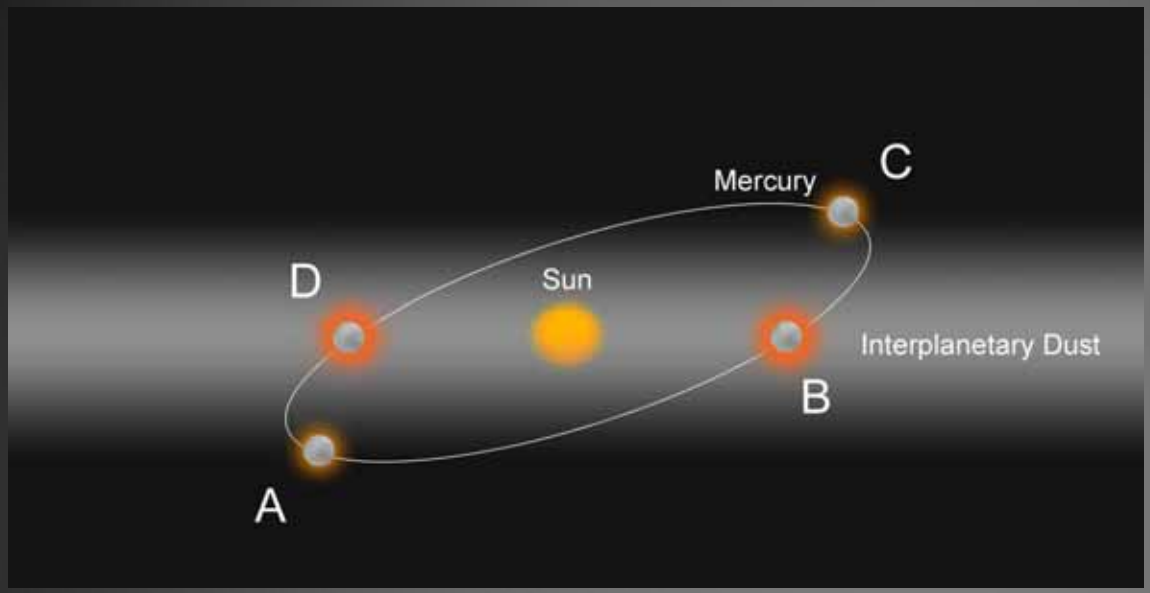
Potter et al., 2008

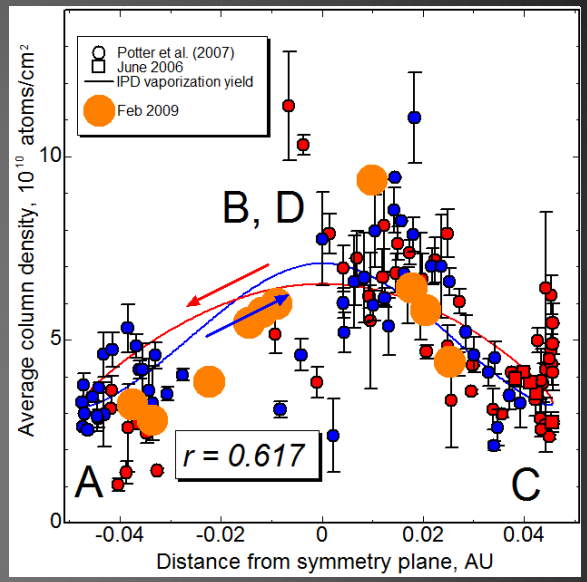


Aug 24, 2008

- Is Solar Wind Sputtering the dominant source process?

Scientific Objectives (new)





Kameda et al., 2009

The orbit plane of Mercury is tilted against the symmetry plane of Interplanetary dust.

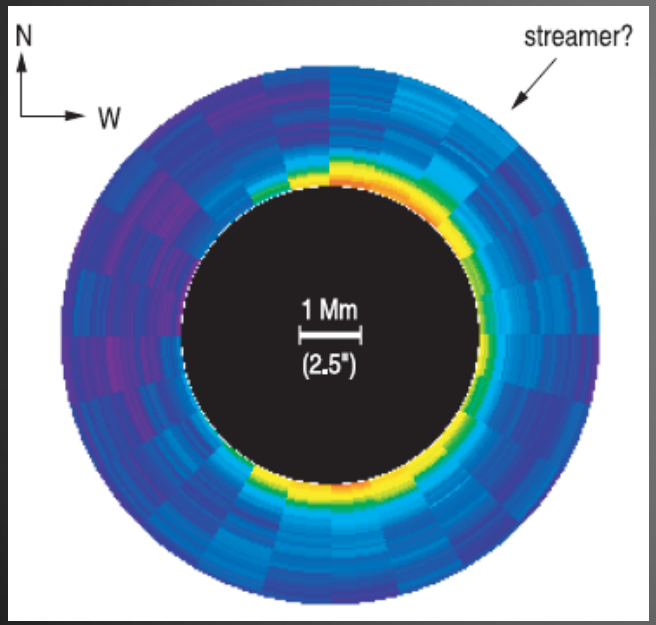
- Is Solar Wind Sputtering the dominant source process? →Various sources

Dawn-Dusk Asymmetry #1

Table 4. SODIUM DIURNAL VARIATION AT MERCURY
Mean low-latitude abundances, 10^{10} atoms cm^{-2}

Early Morning	Mid Morning	Mid Day	Mid Afternnon	Late Afternoon
17.0	19	15	6.7	5.2

Hunten and Sprague, 1997



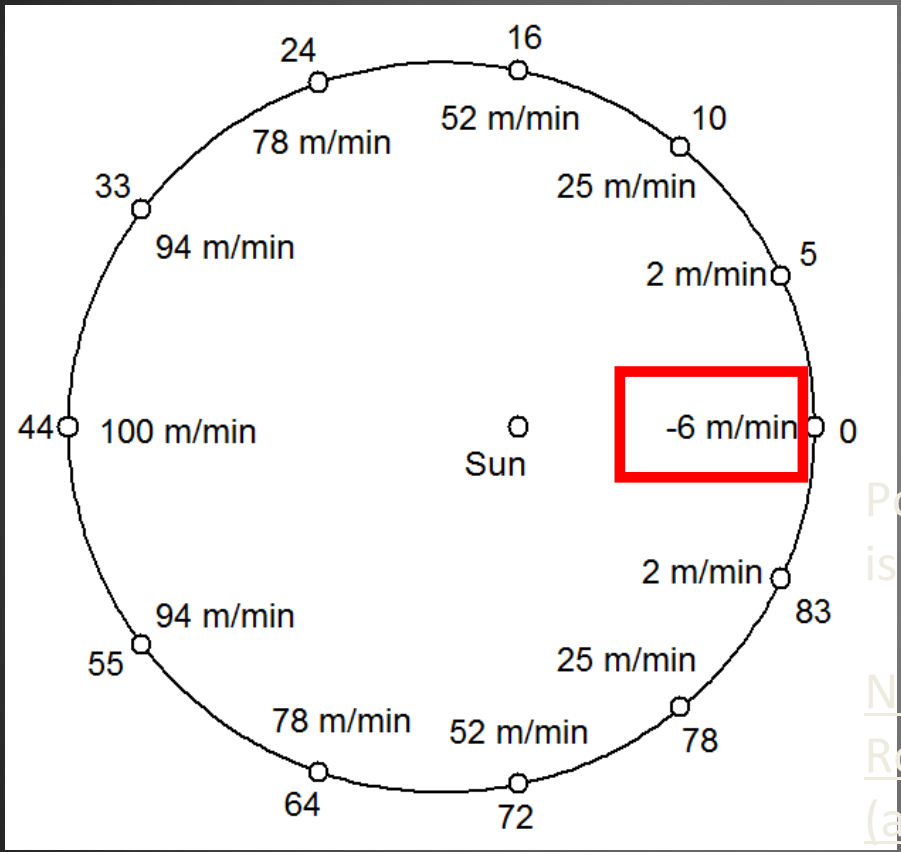
Schleicher et al., 2004

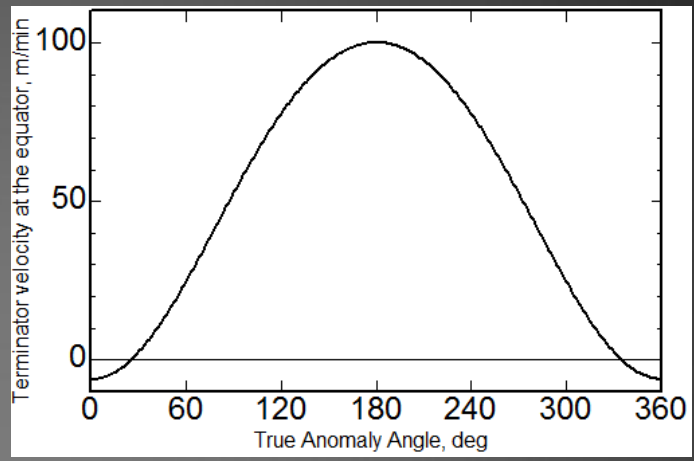
Ground-based observation
↑It is impossible to observe
Dawn and dusk side at the same time.
From statistics,
Sodium density on dawn side is
~3 times higher than that on dusk side
←Dawn-Dusk Asymmetry was observed
at transit.

Sodium adsorbs night side (Low temp)
→is released from dayside.

(or Ion sputtering rate is higher at dawn side)

Dawn-Dusk Asymmetry-2



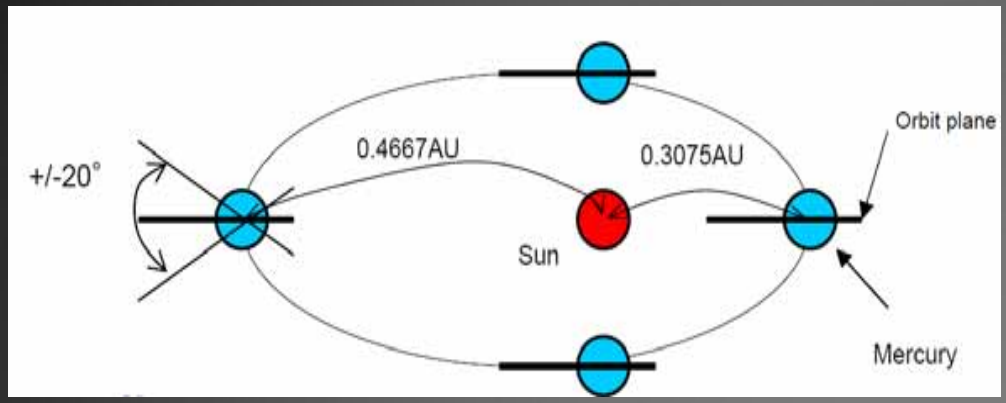


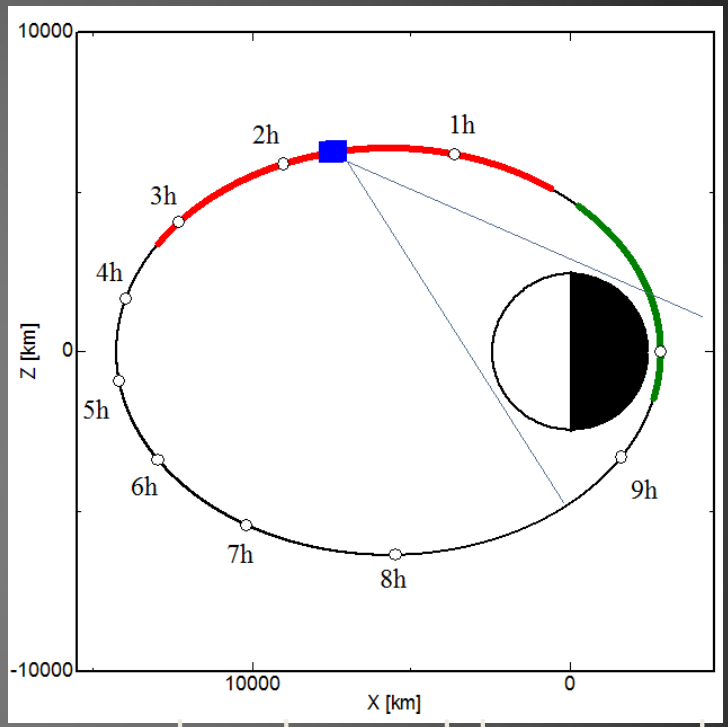
Possibly, sodium in the surface is released and depleted in the morning.

Near perihelion,
Rotation against Sun is reversed
(at the TAA of 25 degrees)

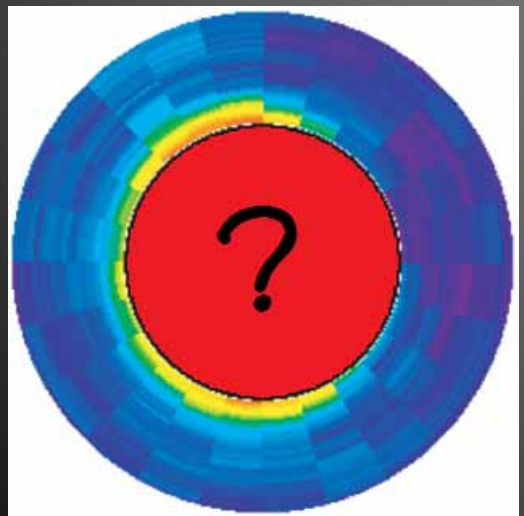
East-West asymmetry may be also reversed??

Dawn-Dusk Asymmetry #3



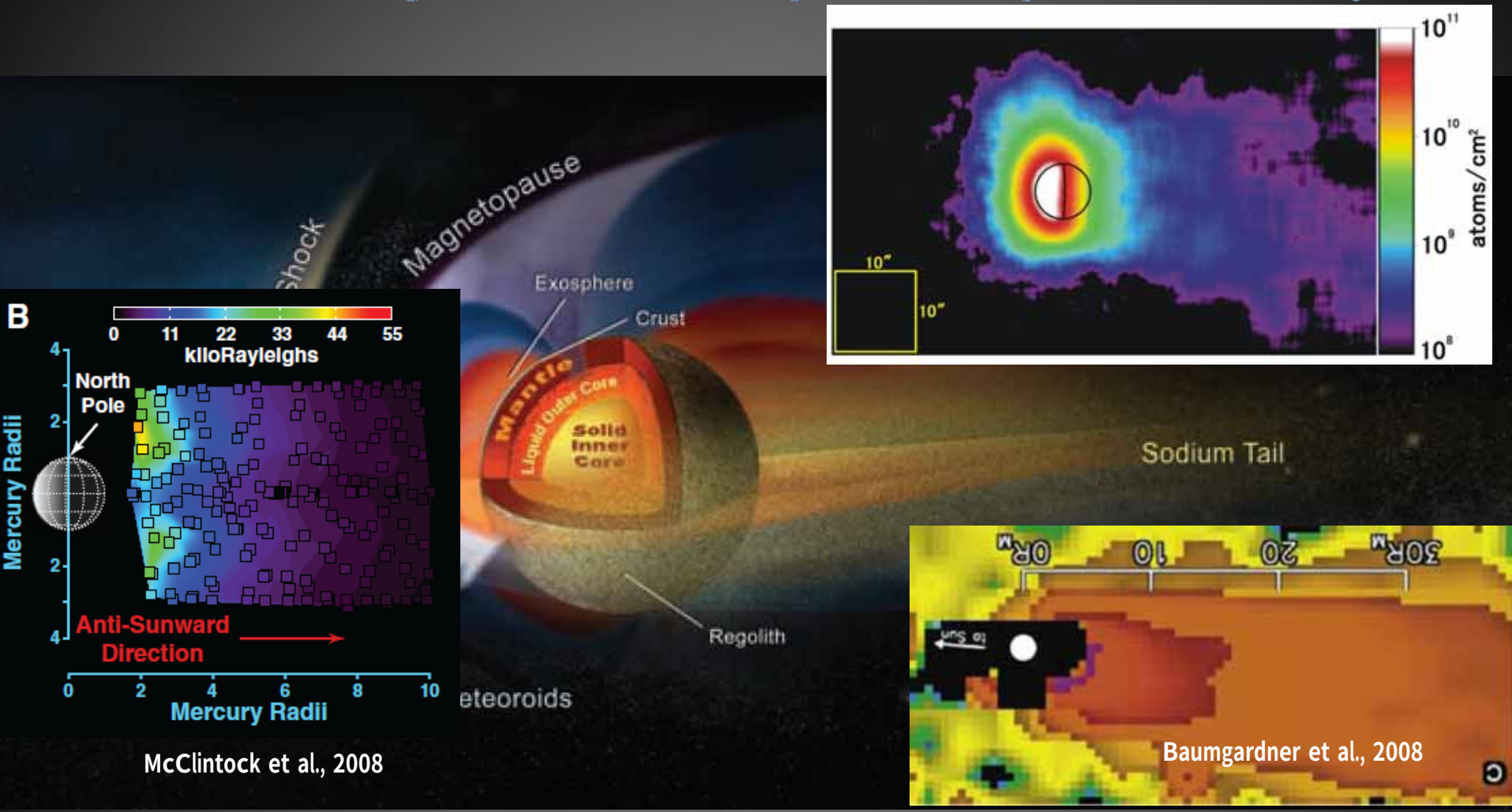


On MMO orbit, we can observe dawn and dusk side simultaneously near Perihelion



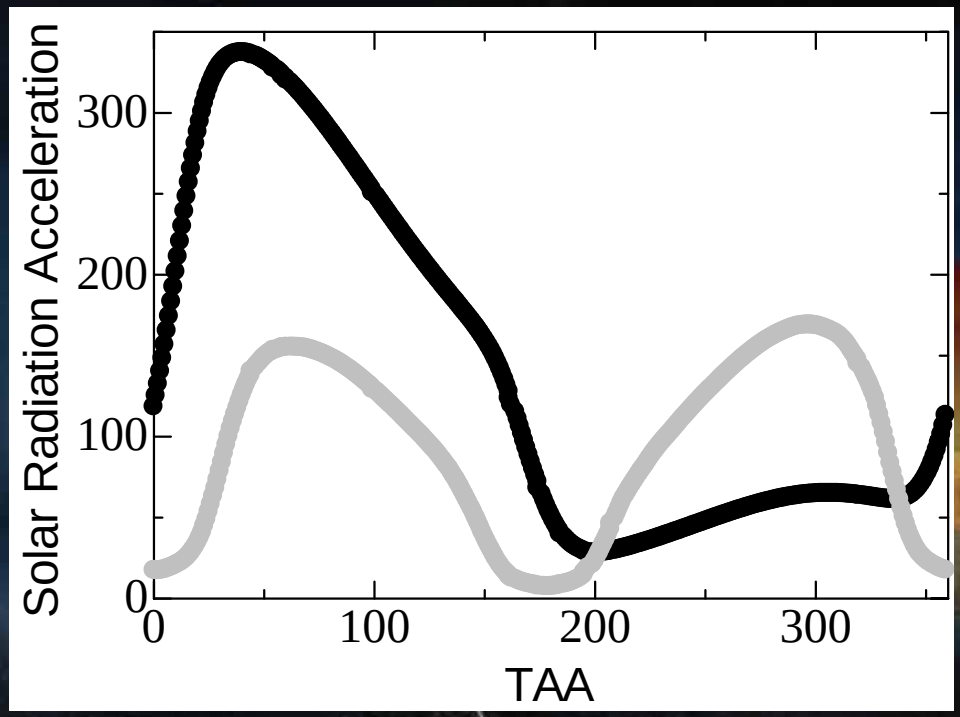
Sodium Exosphere can be observed by ground-based (or Earth orbit) telescope.
However, dayside dawn-dusk side can be observed **only by MSASI**.
20 minutes are needed for observation (inc. preparation time)
↑ Minimum requirement.

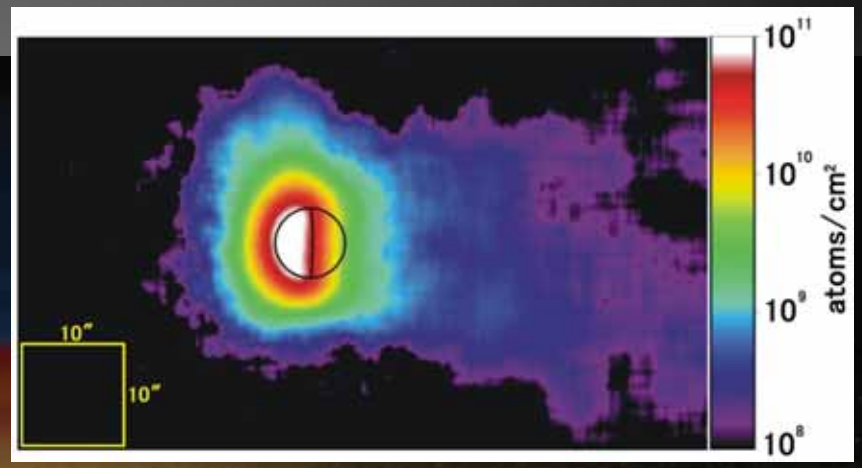
Scientific Objectives: Loss process (Sodium tail)

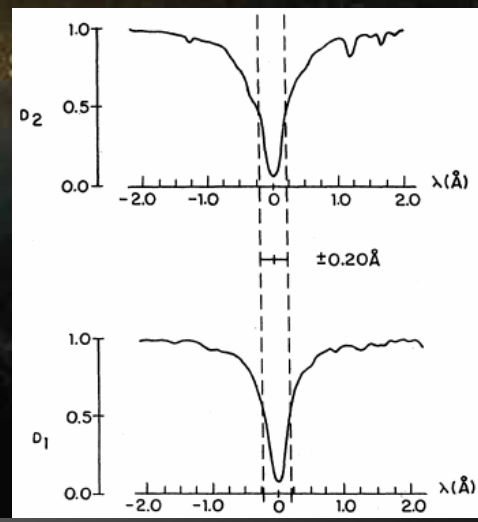


After Na atom is released from the surface of Mercury, it flies under the gravity force and solar radiation pressure. If its release velocity is low, it impacts to the surface and if it is high enough, it gets photoionized by solar UV and picked up by solar wind to the interplanetary space.

Scientific Objectives: Loss process (Solar Radiation Pressure)







Micrometeoroids

Solar radiation pressure depends on True Anomaly Angle.

Gray line shows the result of calculation by Smyth and Marconi, 1995.

Black shows the result of ours.

Na tail will be long at TAA of ~40.

$$A_{ave} = \frac{\int_0^{\infty} A_v \exp(-t/\tau)\, dt}{\int_0^{\infty} \exp(-t/\tau)\, dt}, \frac{dv}{dt} = A_{v'}, v_{t=0} = 0$$

Summary

- Observation of Dayside

  What is source process?

- Temporal variability

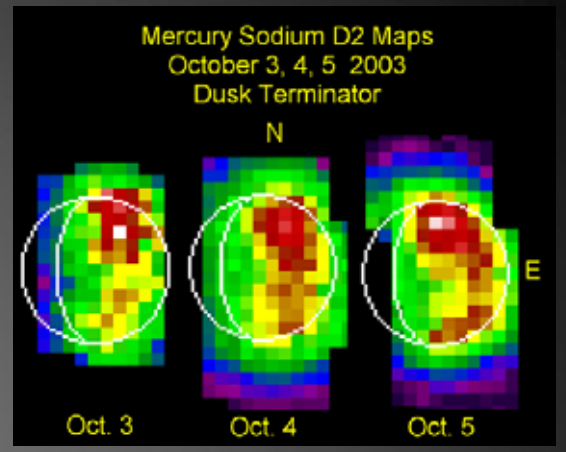
  1 min - 1 day – 88 days

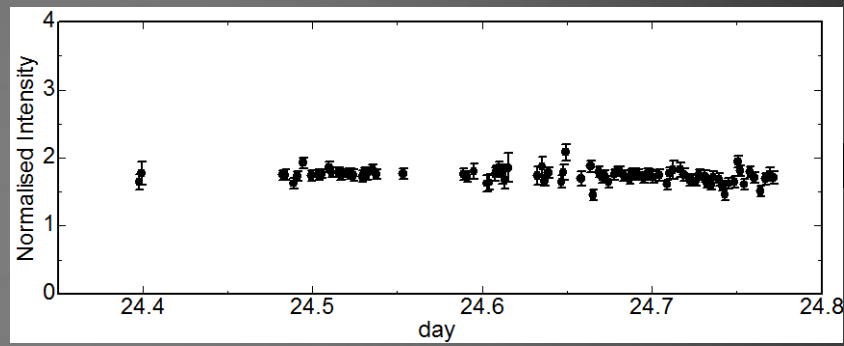
- Sodium tail

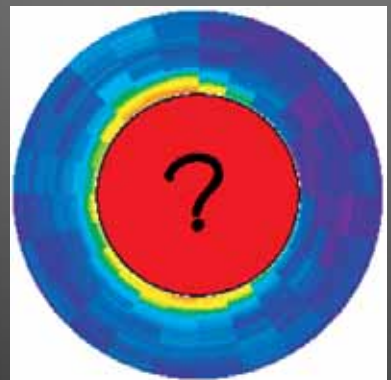
  → Solar radiation pressure

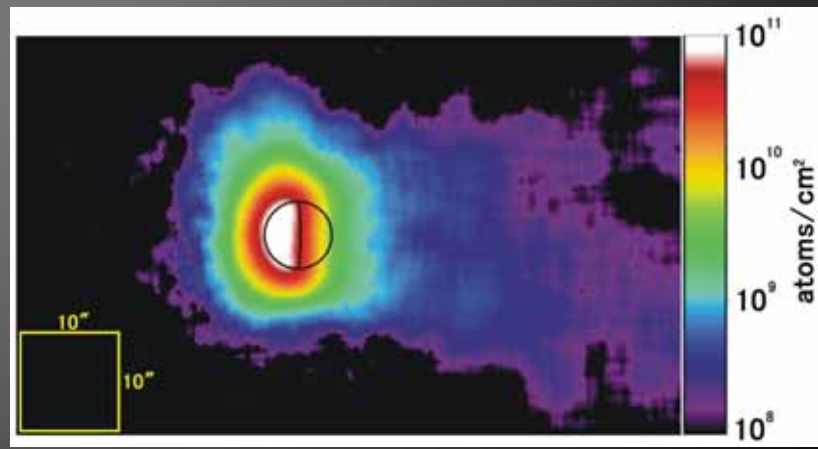
- Dawn-Dusk assymmetry

  →Priority near perihelion

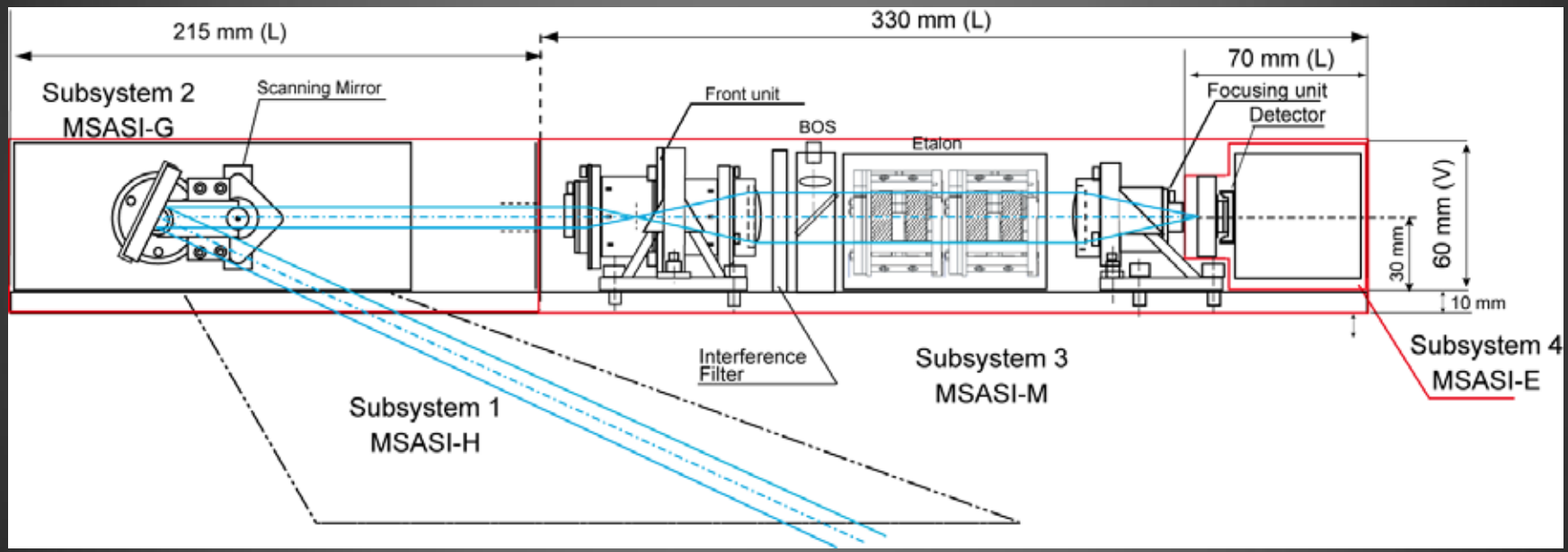






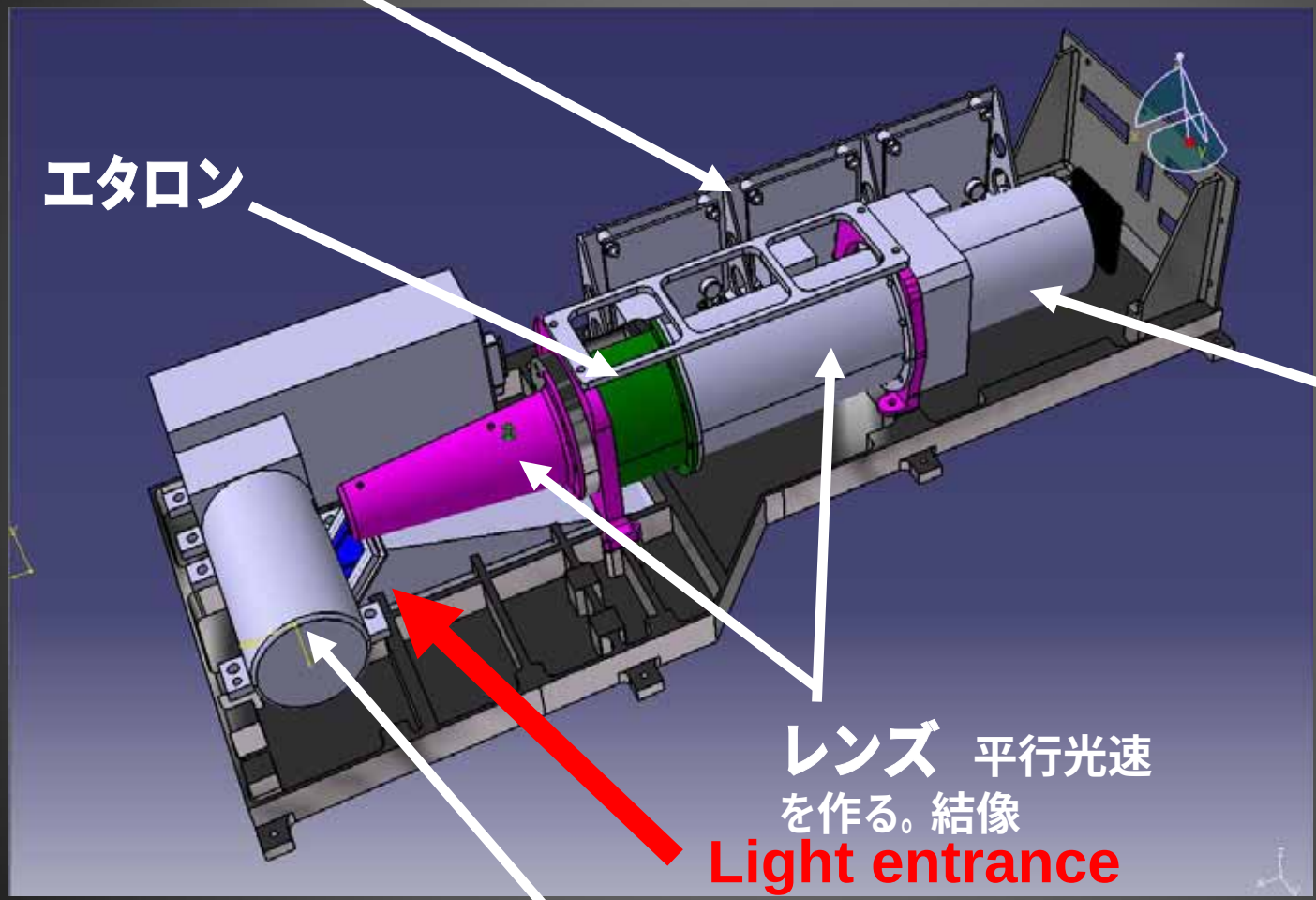


Cross-sectional Diagram

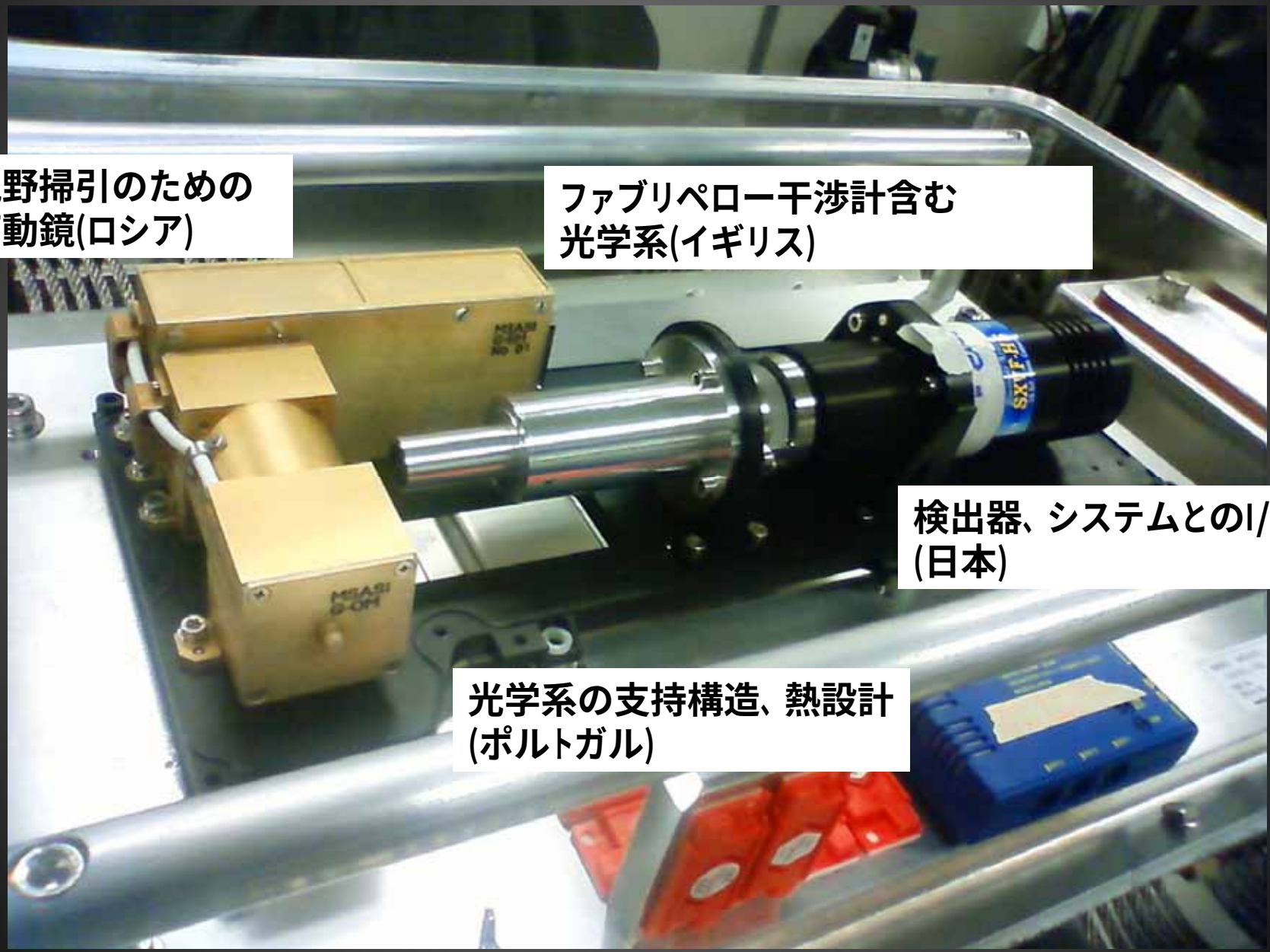


- MSASI-M (メイン), MSASI-H(フード), MSASI-E(エレキ) と3つのパーツに大きく分かれる
- Fabry-Perotエタロンを用いた分光器

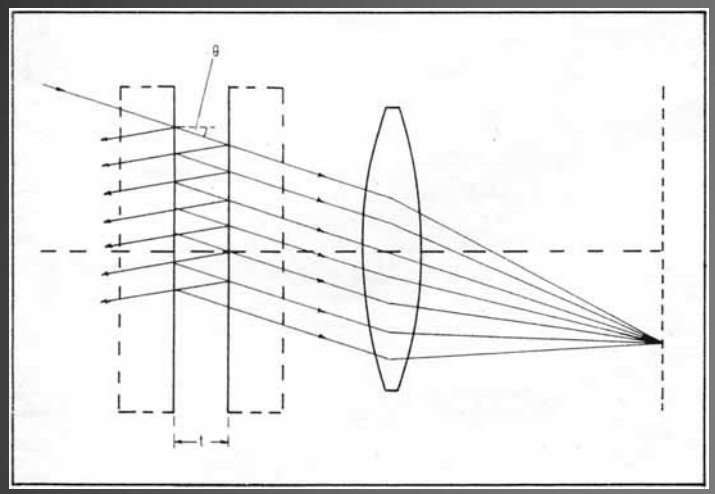
MSASI-M (Main body of the instrument)



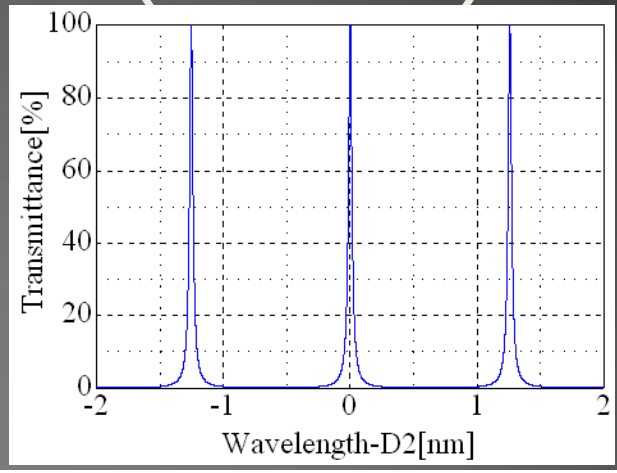
試作機

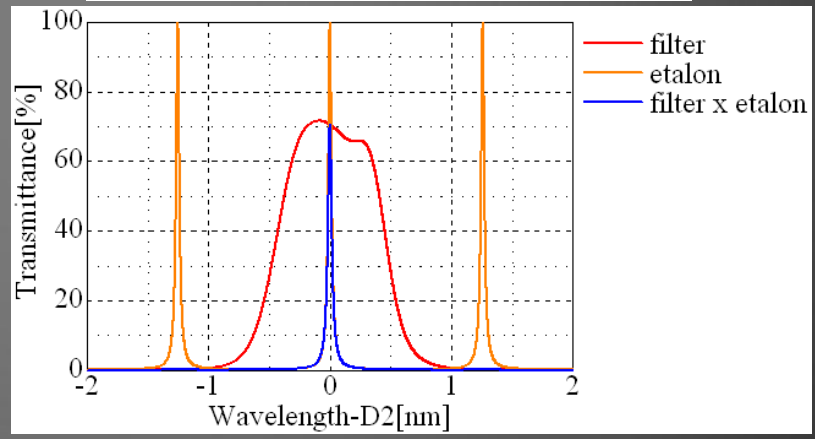

視野掃引のための
可動鏡(ロシア)
ファブリペロー干渉計含む
光学系(イギリス)
検出器、システムとのI/F
(日本)
光学系の支持構造、熱設計
(ポルトガル)

水星大気光観測(MSASI)



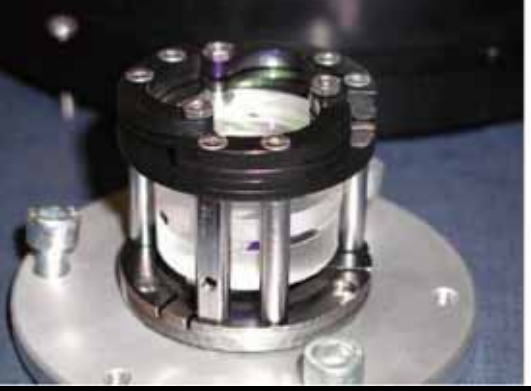
$M\lambda = 2d\cos\theta$

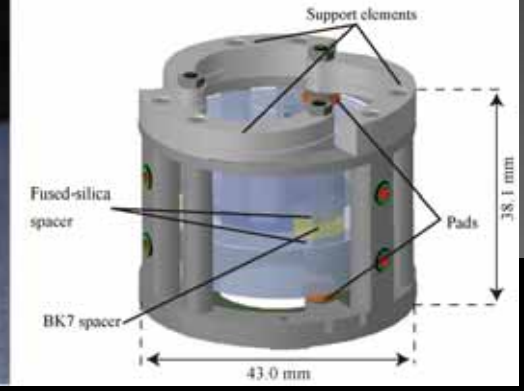




水星ナトリウム大気光カメラで大気分布の時間変化を高い空間分解能($\lambda/\delta\lambda$~85,000)で捉え
↑主に水星昼側で発光　波長分解して輝線を観測する
その後温度ドリフトの小さいフィルタの開発が進んできた→帯域幅0.1nm程度の
フィルタと鏡面スペーサに低熱膨張ガラスを使ったエタロン1個に仕様変更

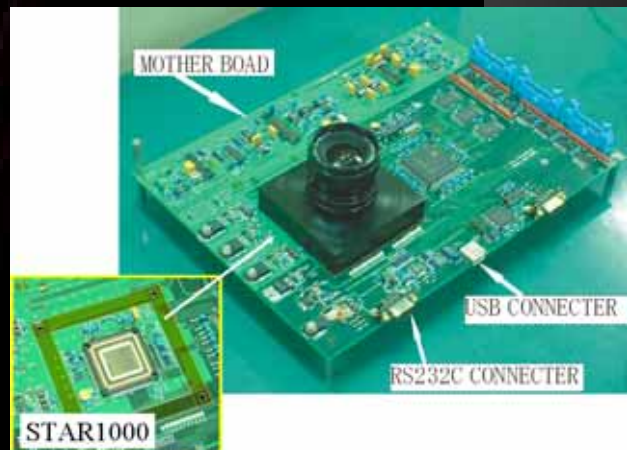
Fabry-Perot interferometer Fringe





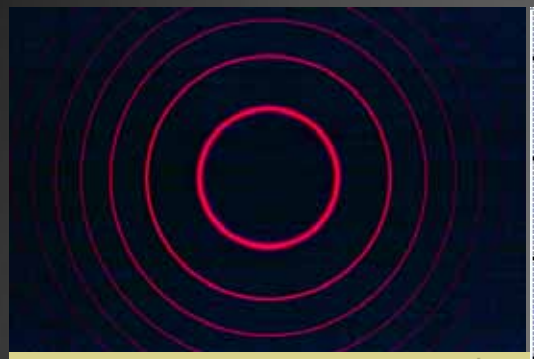
Light source: He-Ne laser (Red)

Detector size



検出器上での波長分布

干渉縞を撮影した画像



$$\lambda_\theta = \lambda_0 \left[1-\left(\frac{Ne}{N^*}\right)^2 \mathrm{Sin}^2\theta \right]^{\frac{1}{2}}$$

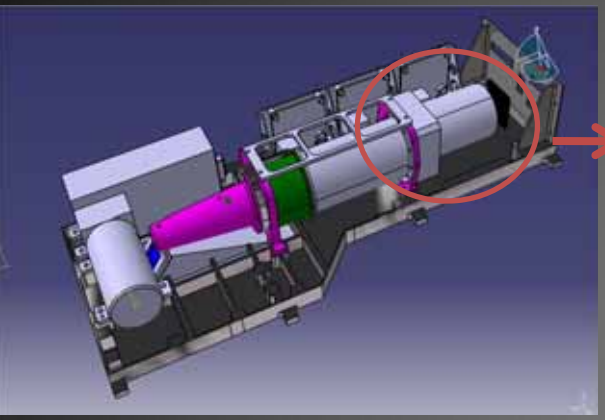
Where:
- λ_θ = Wavelength at angle of incidence
- λ_0 = Wavelength at normal incidence
- Ne = Refractive index of external medium
- N* = Effective refractive index of the filte
- θ = Angle of incidence

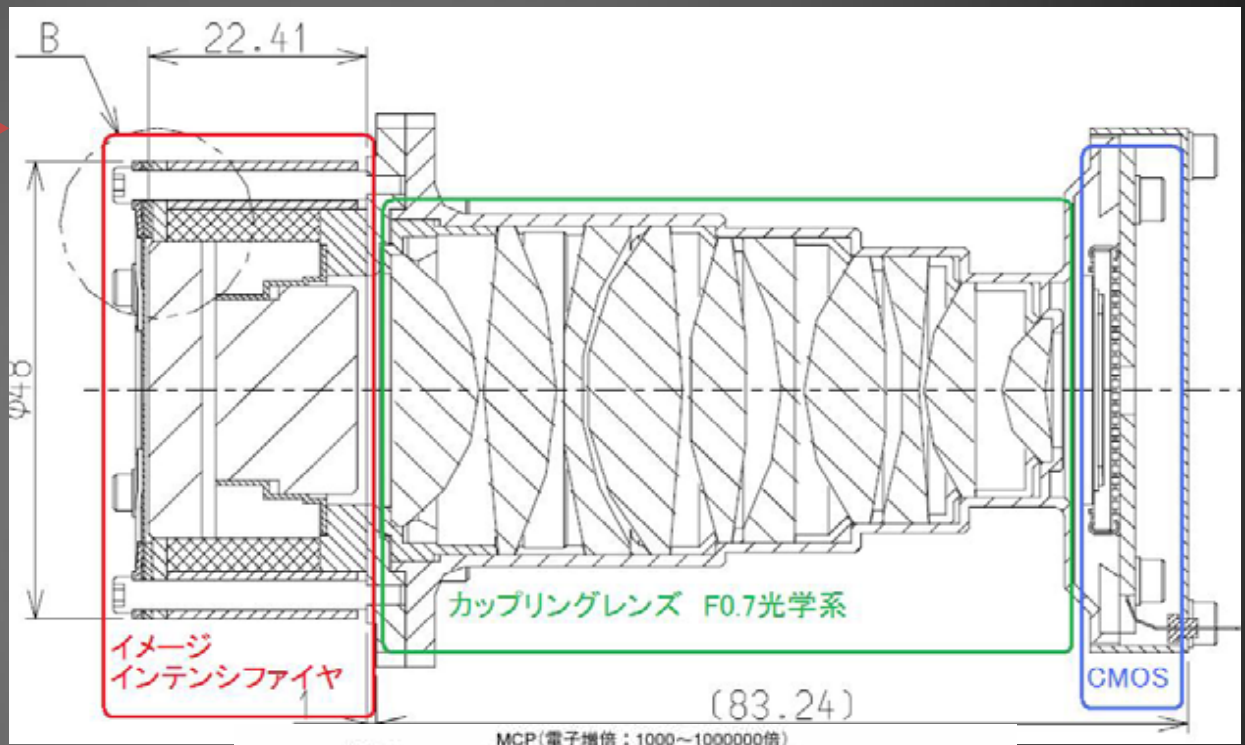
透過波長は
エタロンはcosに比例
フィルタは上式

→エタロン0.65°
フィルタを1.97±0.2°
傾ける

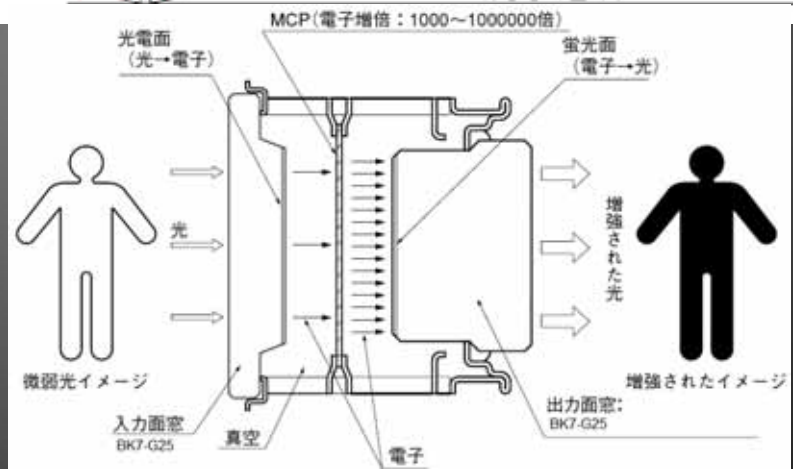
	A	B	C	D	E	F	G	H	I	J
1E	589.1186	589.12786	589.13646	589.14442	589.15174	589.15841	589.16443	589.16981	589.17454	589.17862
1F	589.12368	589.13112	589.13832	589.14528	589.15198	589.15841	589.16455	589.17038	589.17588	589.18099
2E	589.12119	589.13044	589.13905	589.14701	589.15432	589.16099	589.16702	589.17239	589.17712	589.18121
2F	589.12573	589.13325	589.14055	589.14761	589.15443	589.161	589.16731	589.17334	589.17907	589.18446
3E	589.12312	589.13238	589.14099	589.14895	589.15626	589.16293	589.16895	589.17433	589.17906	589.18315
3F	589.12728	589.13487	589.14224	589.14938	589.1563	589.16298	589.16943	589.17563	589.18156	589.18721
4E	589.12442	589.13367	589.14228	589.15024	589.15755	589.16422	589.17025	589.17562	589.18035	589.18444
4F	589.12832	589.13595	589.14337	589.15058	589.15756	589.16433	589.17088	589.1772	589.18329	589.18913
5E	589.12506	589.13432	589.14292	589.15088	589.1582	589.16487	589.17089	589.17627	589.181	589.18508
5F	589.12884	589.1365	589.14394	589.15118	589.1582	589.16501	589.17161	589.178	589.18417	589.19013
6E	589.12506	589.13432	589.14292	589.15088	589.1582	589.16487	589.17089	589.17627	589.181	589.18508
6F	589.12884	589.1365	589.14394	589.15118	589.1582	589.16501	589.17161	589.178	589.18417	589.19013
7E	589.12442	589.13367	589.14228	589.15024	589.15755	589.16422	589.17025	589.17562	589.18035	589.18444
7F	589.12832	589.13595	589.14337	589.15058	589.15756	589.16433	589.17088	589.1772	589.18329	589.18913
8E	589.12312	589.13238	589.14099	589.14895	589.15626	589.16293	589.16895	589.17433	589.17906	589.18315
8F	589.12728	589.13487	589.14224	589.14938	589.1563	589.16298	589.16943	589.17563	589.18156	589.18721
9E	589.12119	589.13044	589.13905	589.14701	589.15432	589.16099	589.16702	589.17239	589.17712	589.18121
9F	589.12573	589.13325	589.14055	589.14761	589.15443	589.161	589.16731	589.17334	589.17907	589.18446
10E	589.1186	589.12786	589.13646	589.14442	589.15174	589.15841	589.16443	589.16981	589.17454	589.17862
10F	589.12368	589.13112	589.13832	589.14528	589.15198	589.15841	589.16455	589.17038	589.17588	589.18099

検出器の温度試験



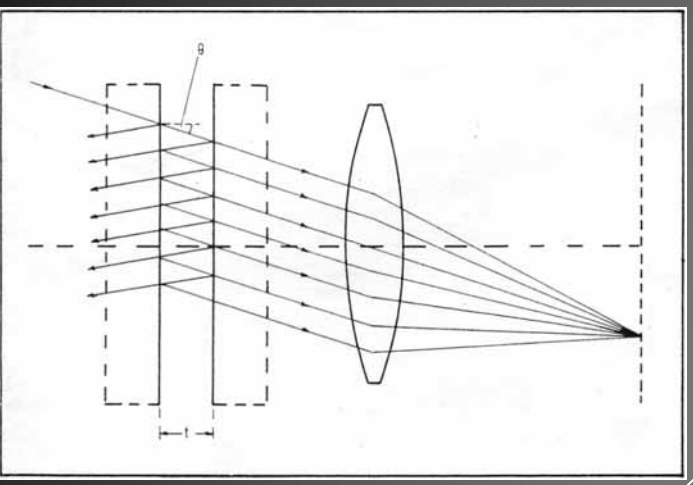


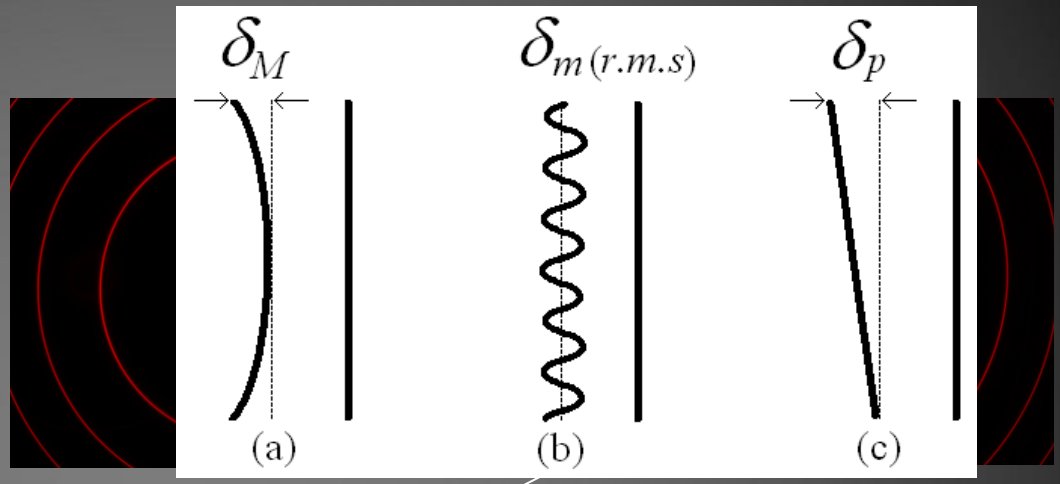
イメージインテンシファイヤの像をCMOS上に転送

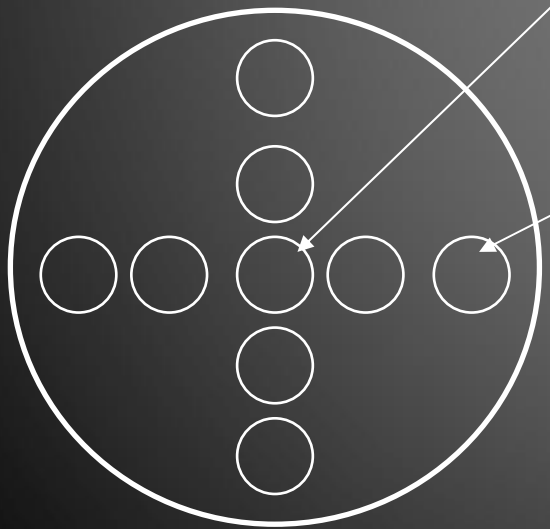


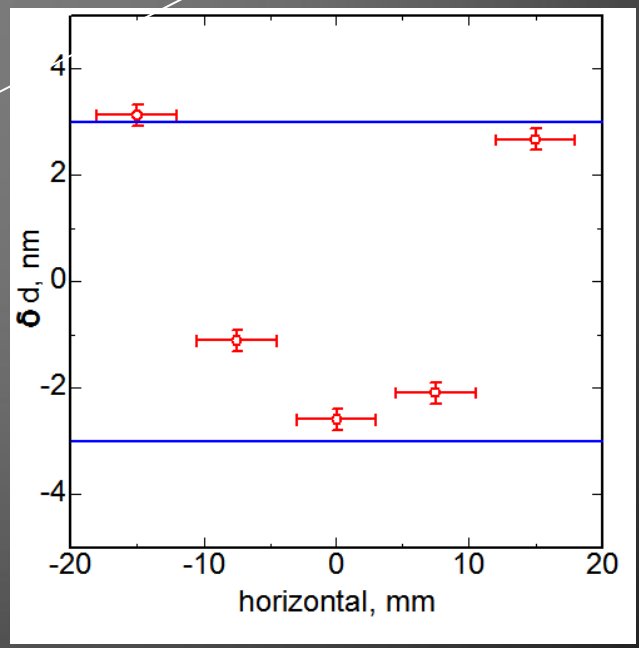
温度変化に伴う焦点距離の変化でフォーカスがずれる？
来週から試験予定

高精度平面研磨技術

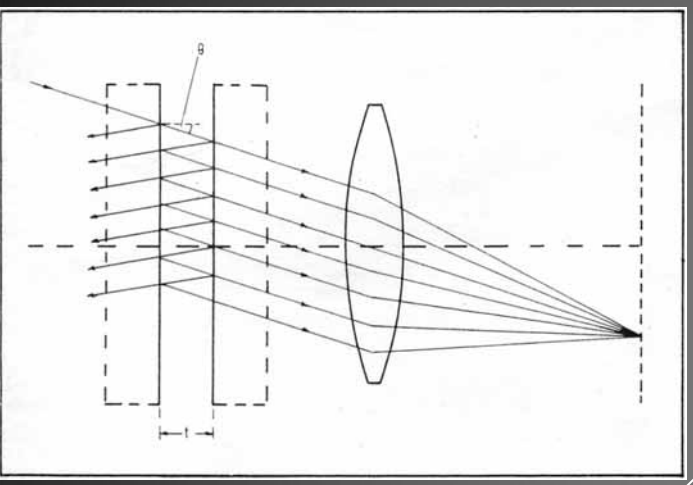


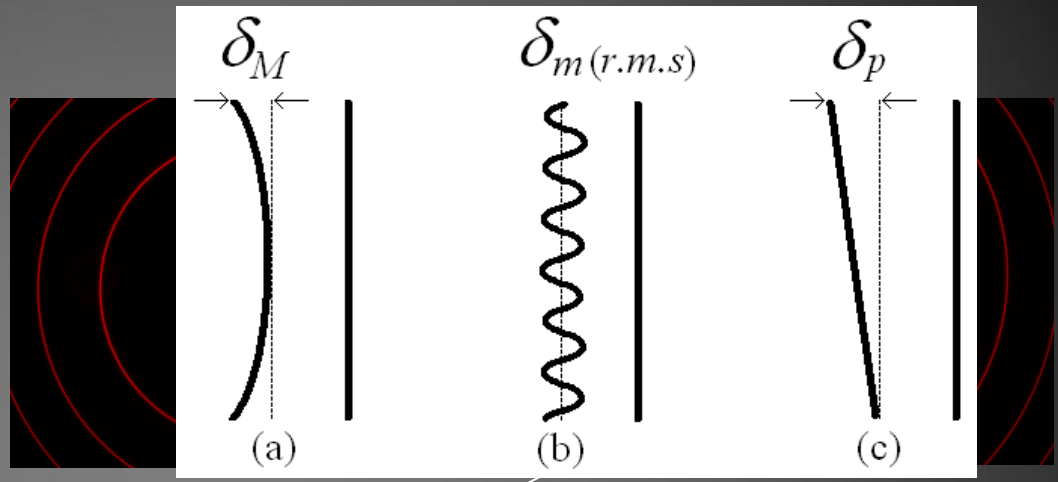

δ_M
$\delta_{m\,(r.m.s)}$
δ_p
(a)
(b)
(c)

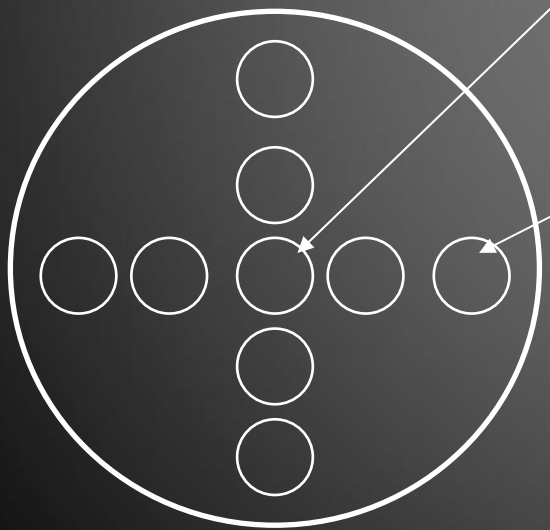


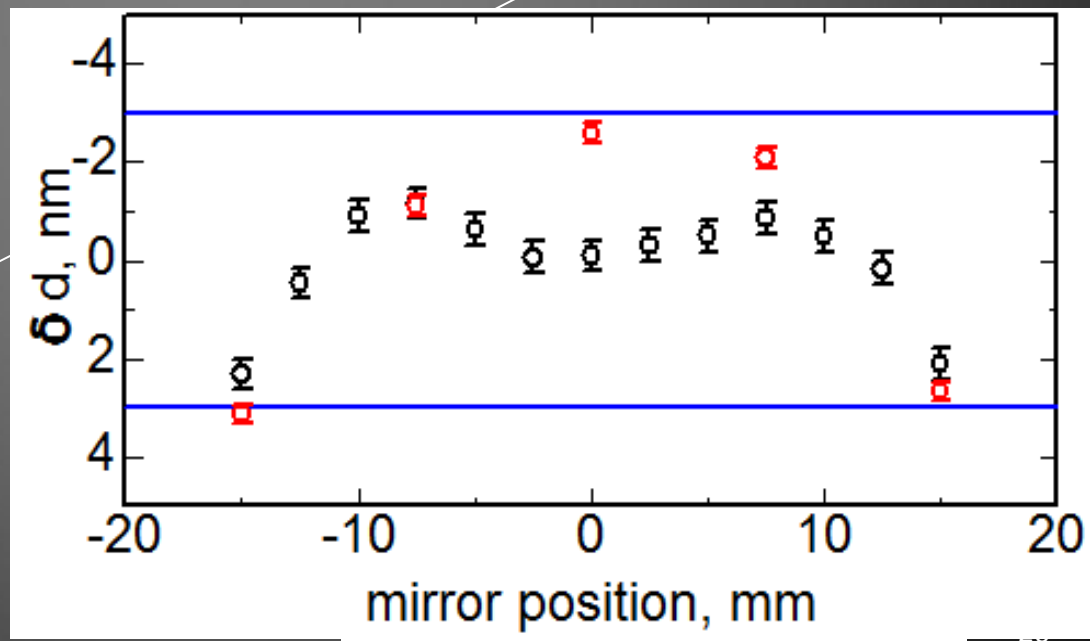

δ d, nm
4
2
0
-2
-4
-20
-10
0
10
20
horizontal, mm

高精度平面研磨技術




δ_M
$\delta_{m\,(r.m.s)}$
δ_p
(a)
(b)
(c)




δd, nm
-4
-2
0
2
4
-20
-10
0
10
20
mirror position, mm

まとめ

- 水星ナトリウム大気光観測器MSASIの紹介
- 観測目的
  - 昼側の大気密度
  - 太陽風フラックスと密度
  - ダスト分布　朝夕の非対称
- 観測器の構成
- 高精度平面研磨技術へ

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