Un optional spettroscopico per PRISMA

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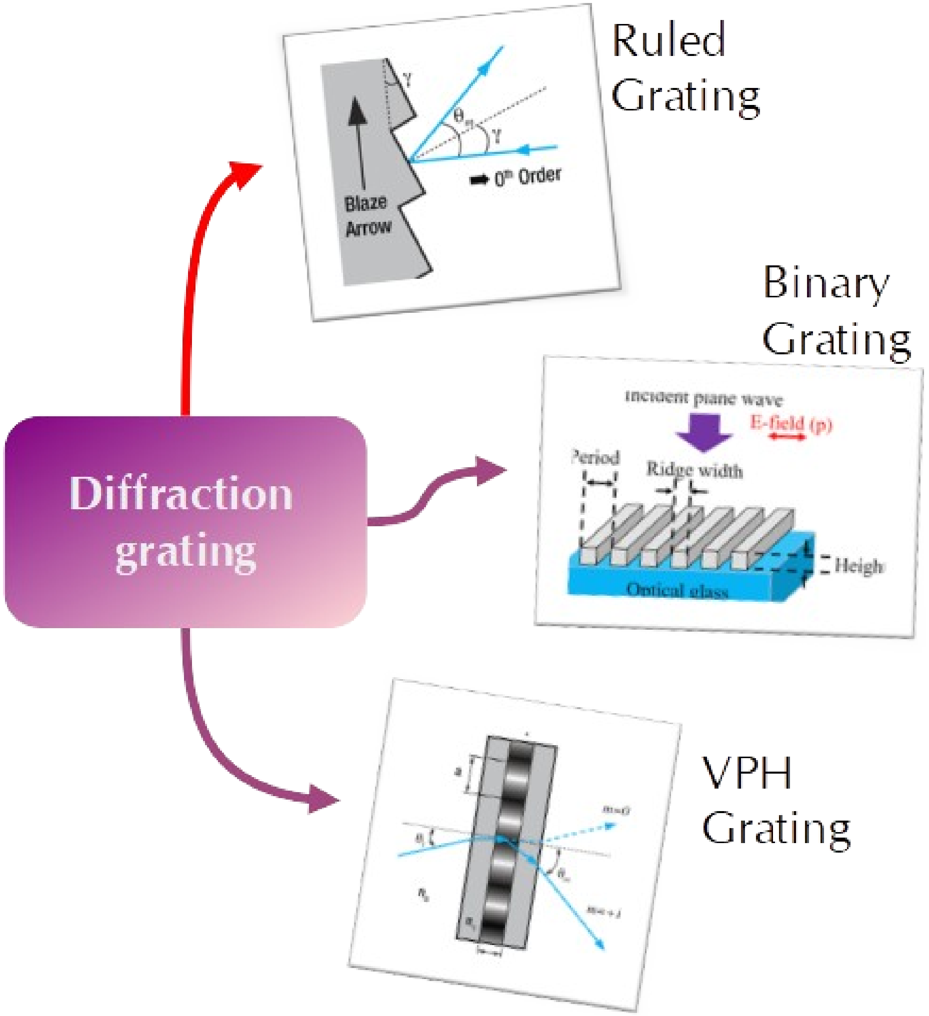
Diffraction gratings in astronomy

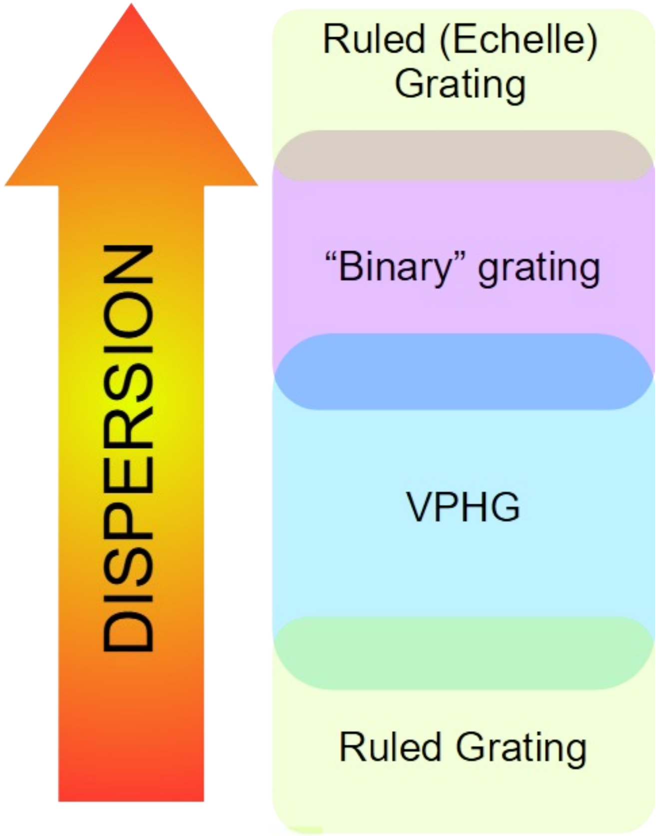
"Let in the sun's light, by a small hole to a darkened house, and at the hole place a feather (the more delicate and white the better for this purpose)...a number of small circles and ovals (appear), **one is somewhat white and all the rest severally coloured.**"

$$R = \frac{\lambda}{\Delta\lambda}$$

James Gregory
(1638-1675)

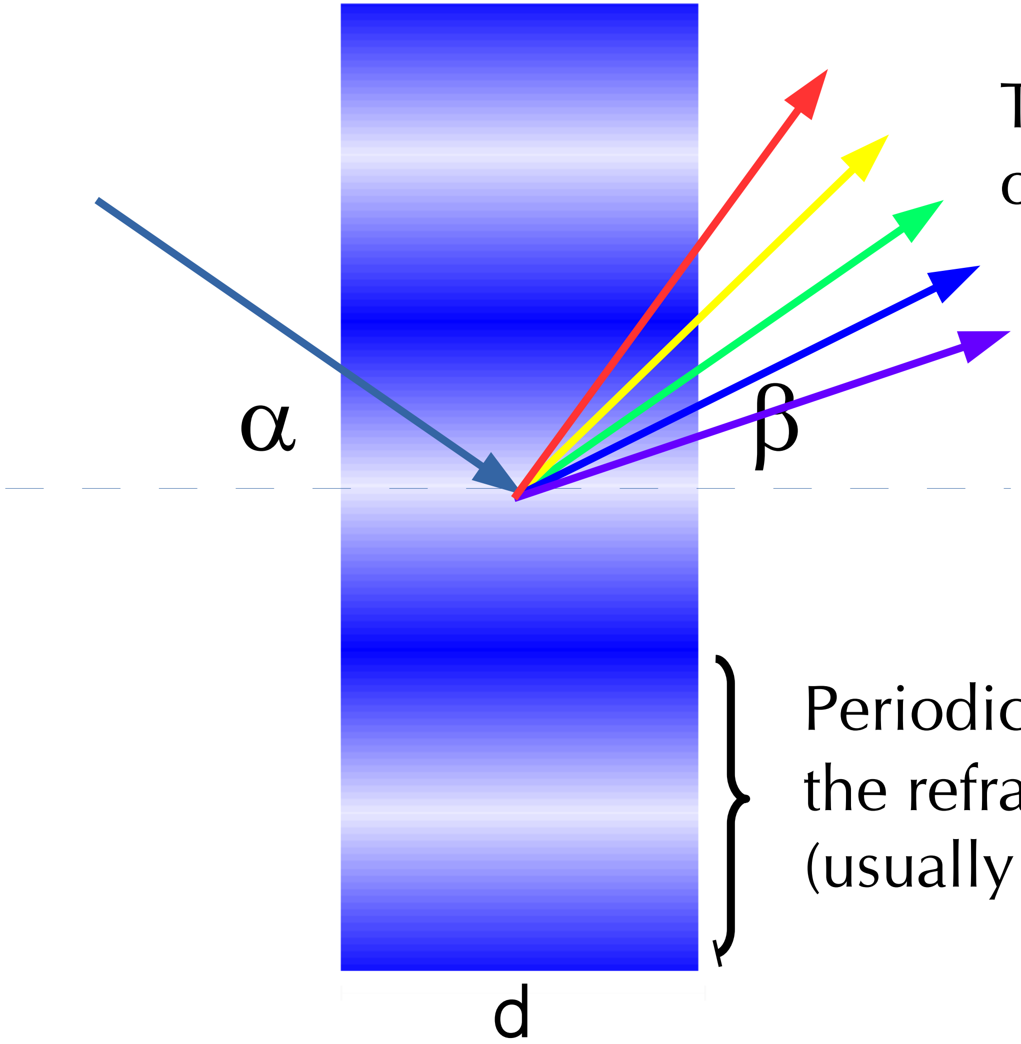
Diffraction gratings: possibilities





$$D = \frac{d\beta}{d\lambda} = \frac{mG}{\cos\beta}$$

VPHG: principle of work



The diffraction occurs thanks to a periodic modulation of the refractive index in the volume of the material.

Periodic modulation of the refractive index Δn (usually sinusoidal).

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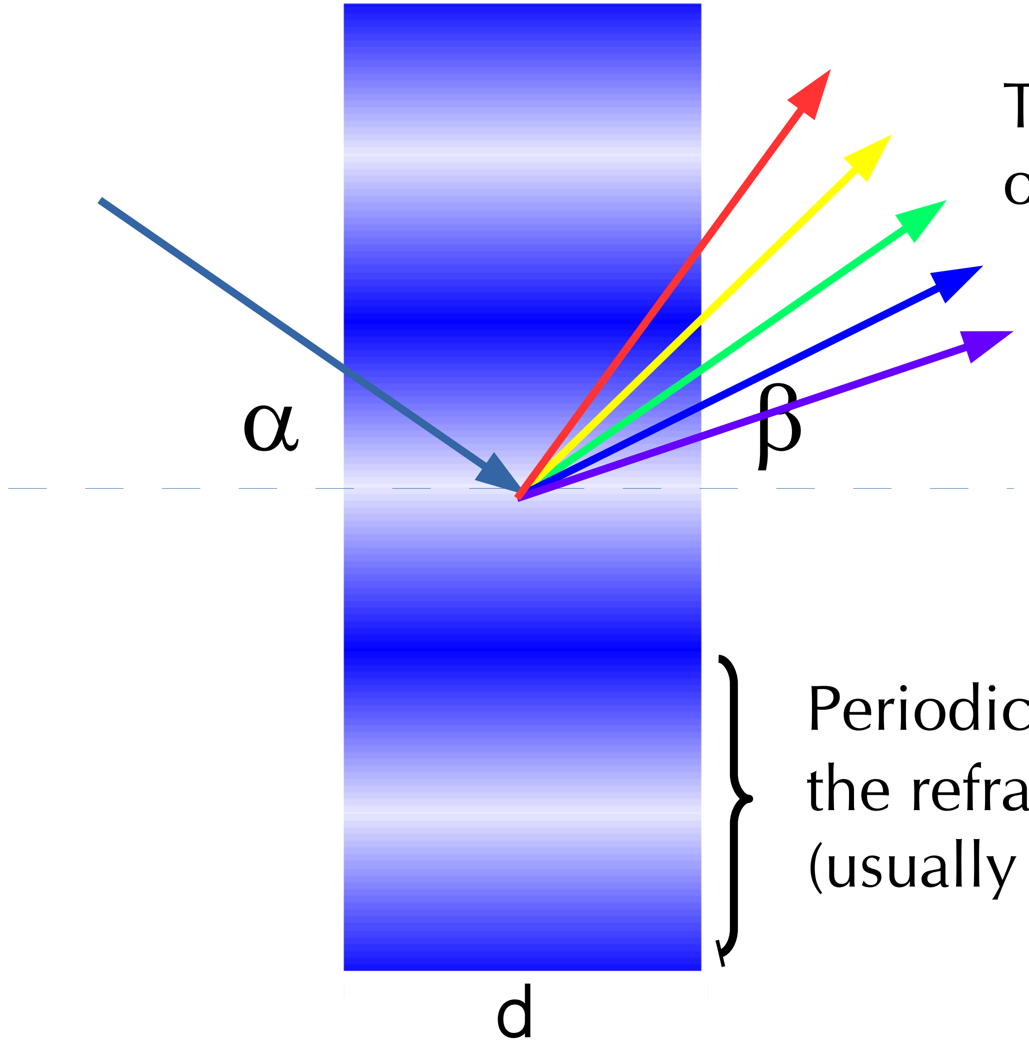

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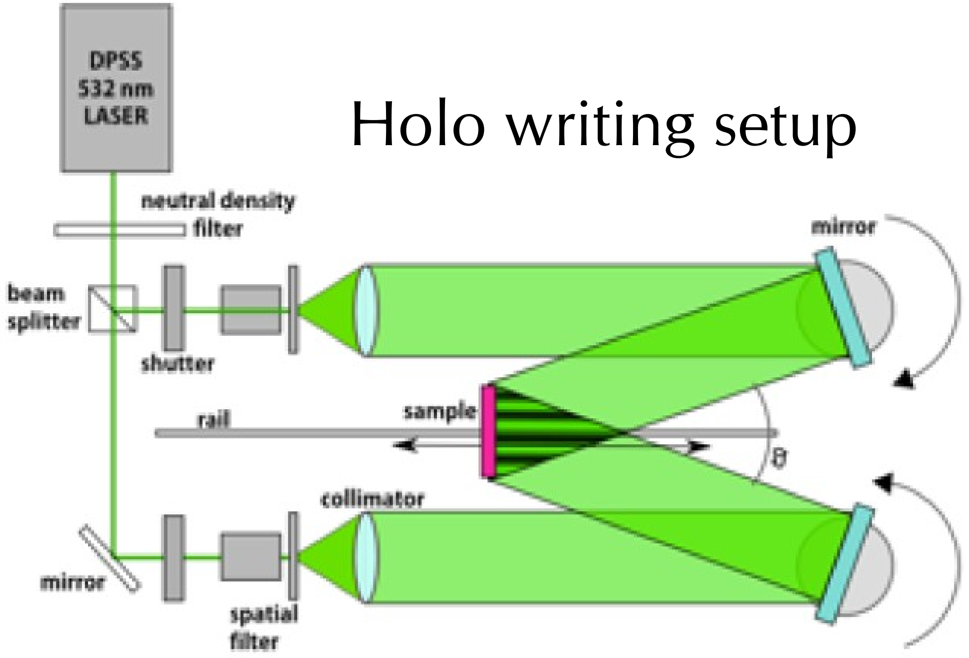
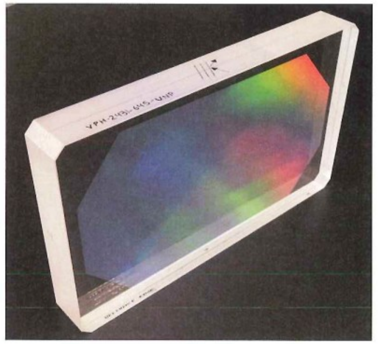
Holo writing setup



VPHG: main features for astronomy



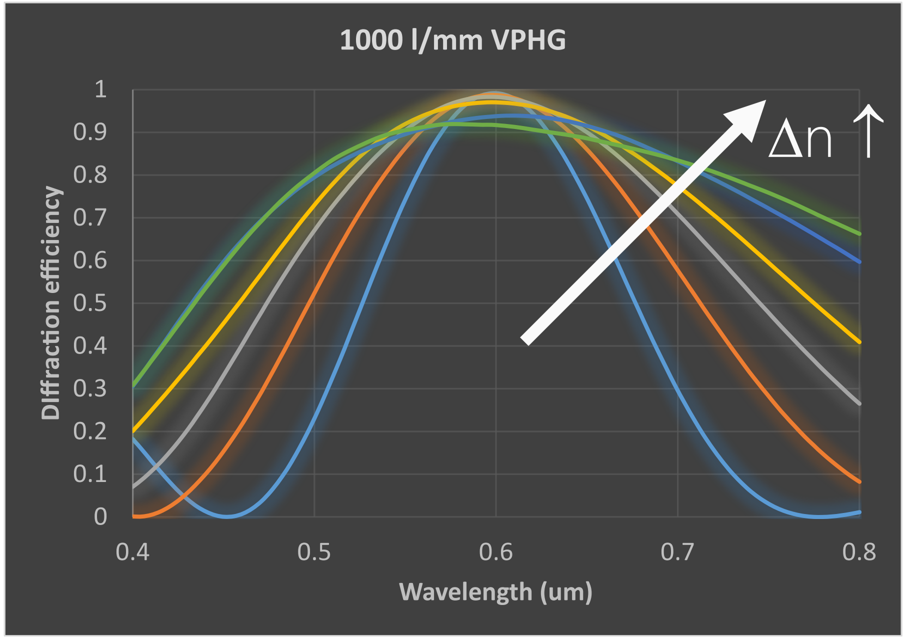
- The peak efficiency can be easily > 90%; **large bandwidth** if we can store a high Δn;

- The device is **easily customizable** from UV to NIR and multi-functional structures can be obtained (multi order, multiplexed);

- Especially suitable for **low and medium dispersion** spectrographs;

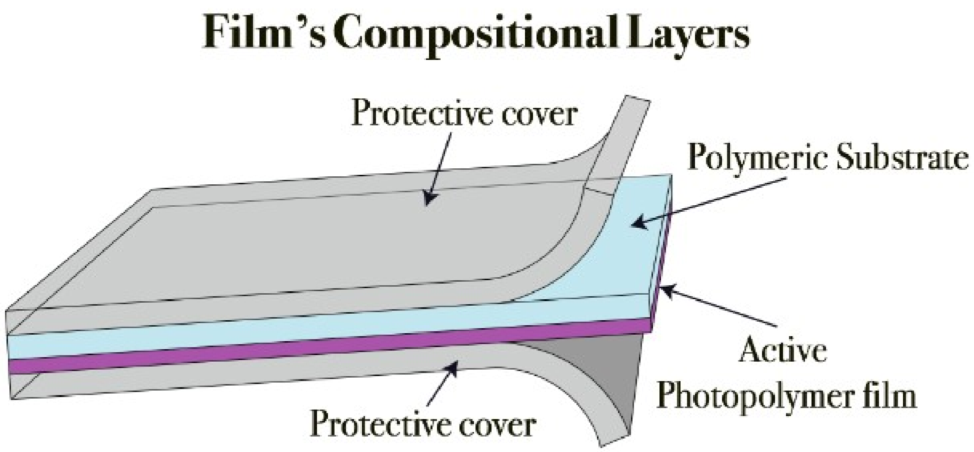
- **Reliable and repeatable** design process;

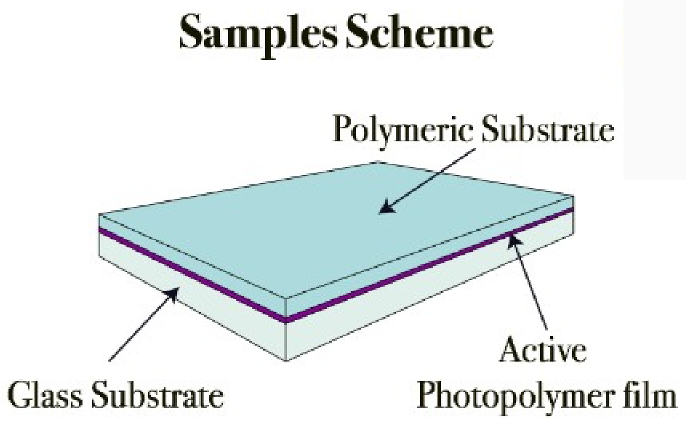
- **Fast production and characterization process** suited for multi VPH copies.



Materials for VPHGs: photopolymers

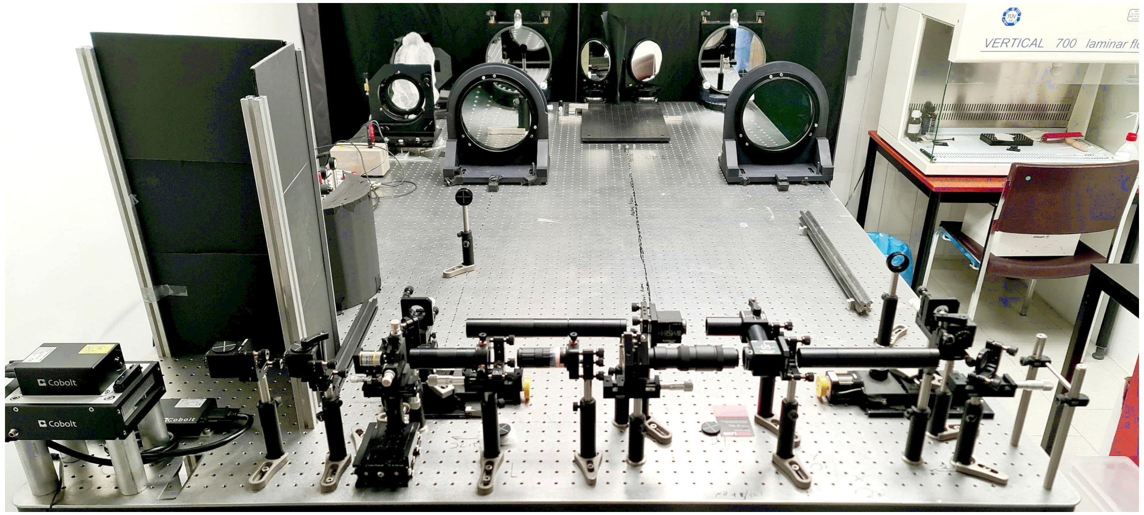
Photopolymers are available showing a very simple and "easy to use" structure:



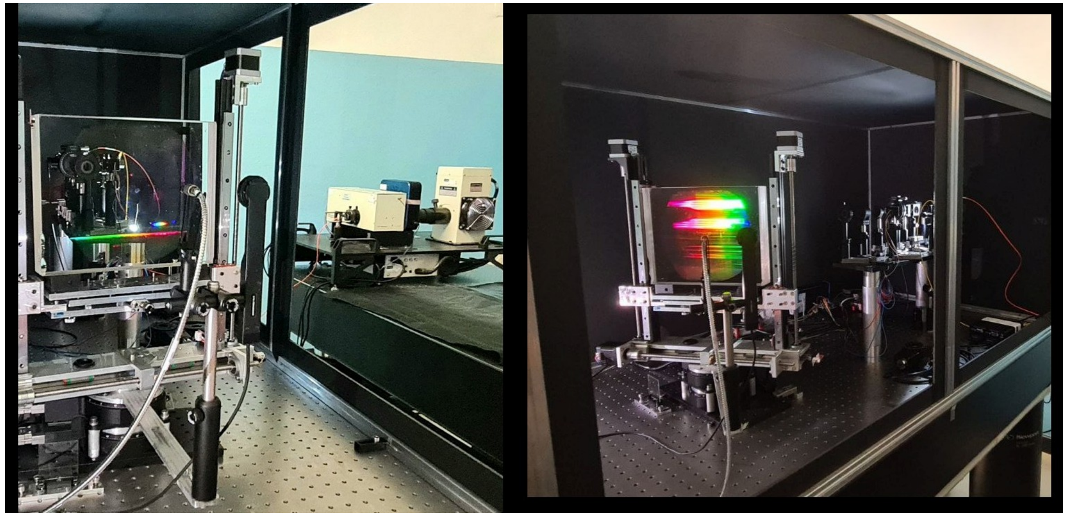


- The structure is like a protective layer of smartphone and tablet;
- They can show different thicknesses and size;
- The holograms can be removed and attached to different substrates like the protective layers.

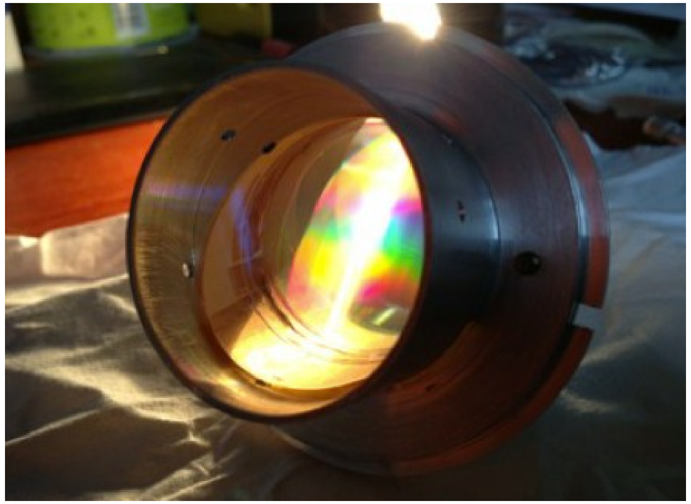
Actual capabilities @ INAF – OABr

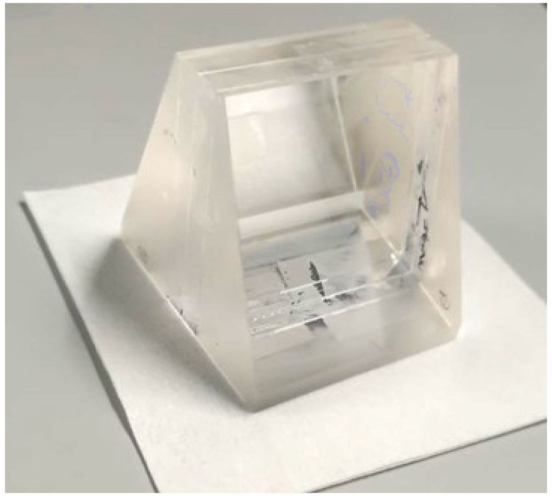


Writing capabilities
- RGB laser system;
- Size up to 190 mm x 200 mm;
- Line density: 200 – 3000 l/mm;
- Spectral range: 0.33 – 2.5 um;
- VPHGs and GRISMs.



Characterization capabilities
- Fully automatic measurements;
- Diffraction efficiency from UV to NIR;
- Efficiency map (X – Y);
- Line density (< 0.5 l/mm) and orientation;
- WFE distortion.






K
H
J
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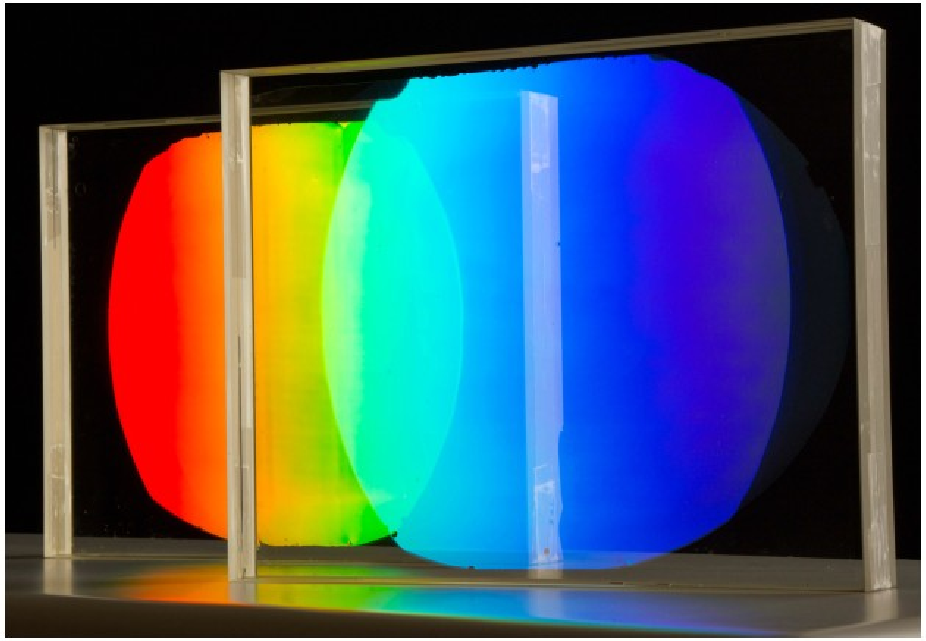
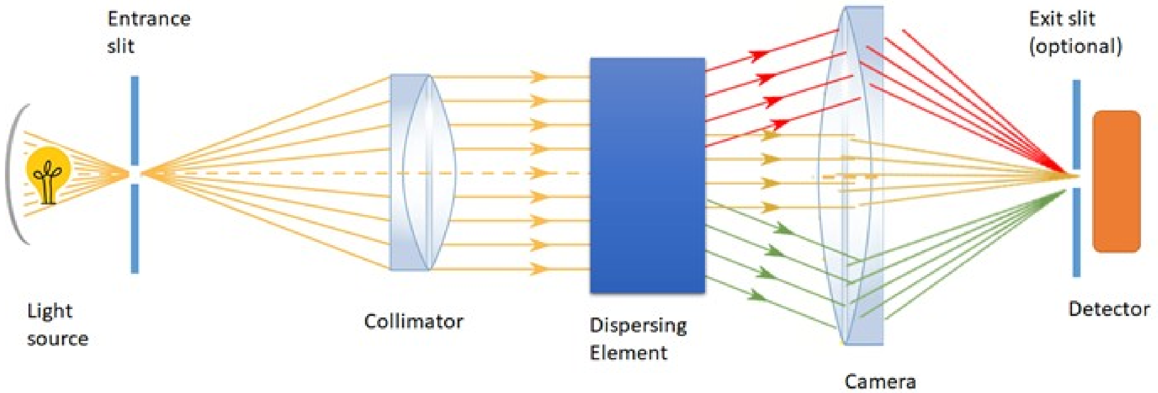


PRISMA Camera with spectral capabilities: issues

- Usually a spectrograph is attached to the main optics:

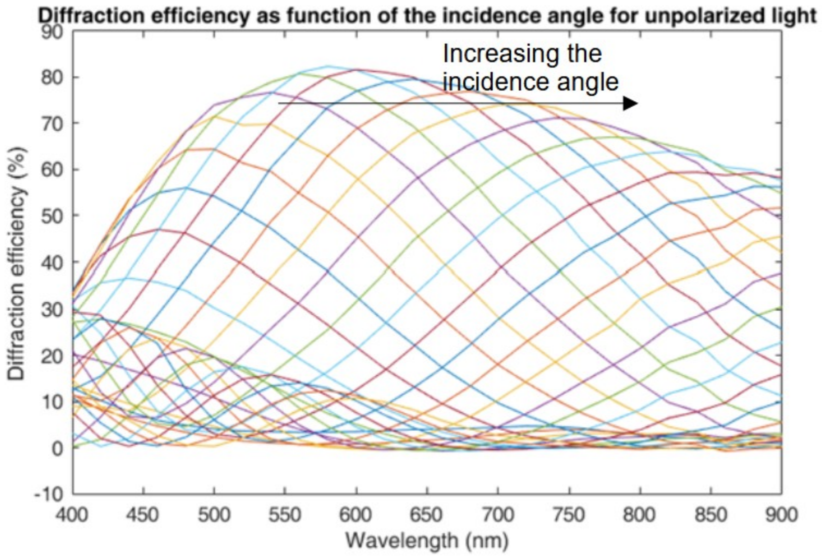


Not so easy in PRISMA camera, because of the extremely wide field of view and compactness.

- A different approach is to place a dispersing element in front of the main optics: a collimated beam is coming from the sky and the camera forms the spectrum on the CMOS detector.

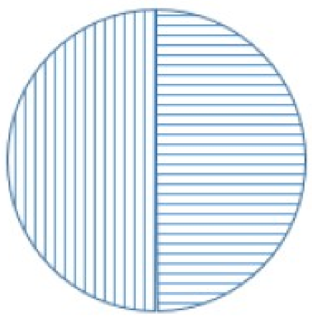
Key points of the dispersing element

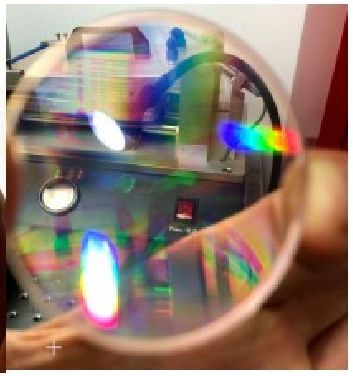
- What the spectral range of interest?
- The dispersion/resolution provided by the grating cannot be too large;
- The response of the grating depends on the target position/trajectory
- The throughput decreases (reflection losses, diffraction efficiency,...);
- Example of the efficiency curve at t are the following:



Overcoming the direction uncertainty

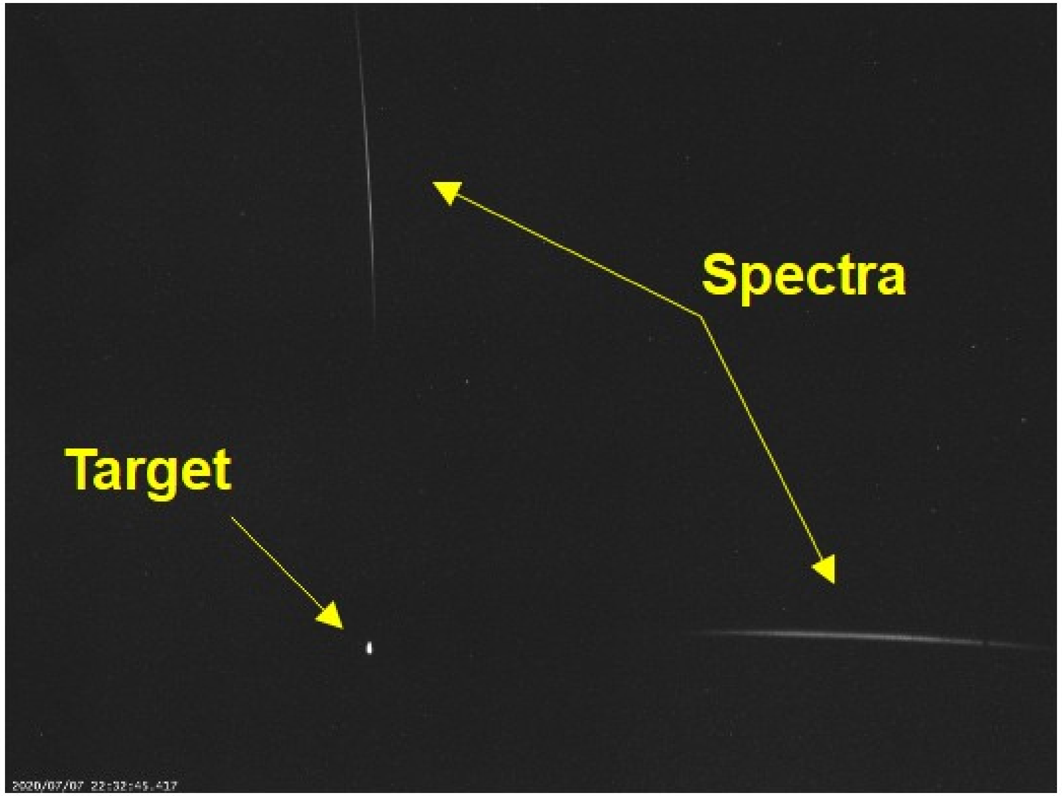
- The grating is divided in two sections with patterns at 90°: criss-cross;
- The throughput is lower;
- The robustness is much bigger: no matter the object comes, a “good” spectrum is recorded;
- This has been done for AMOS camera (Slovak Video Meteor Network).

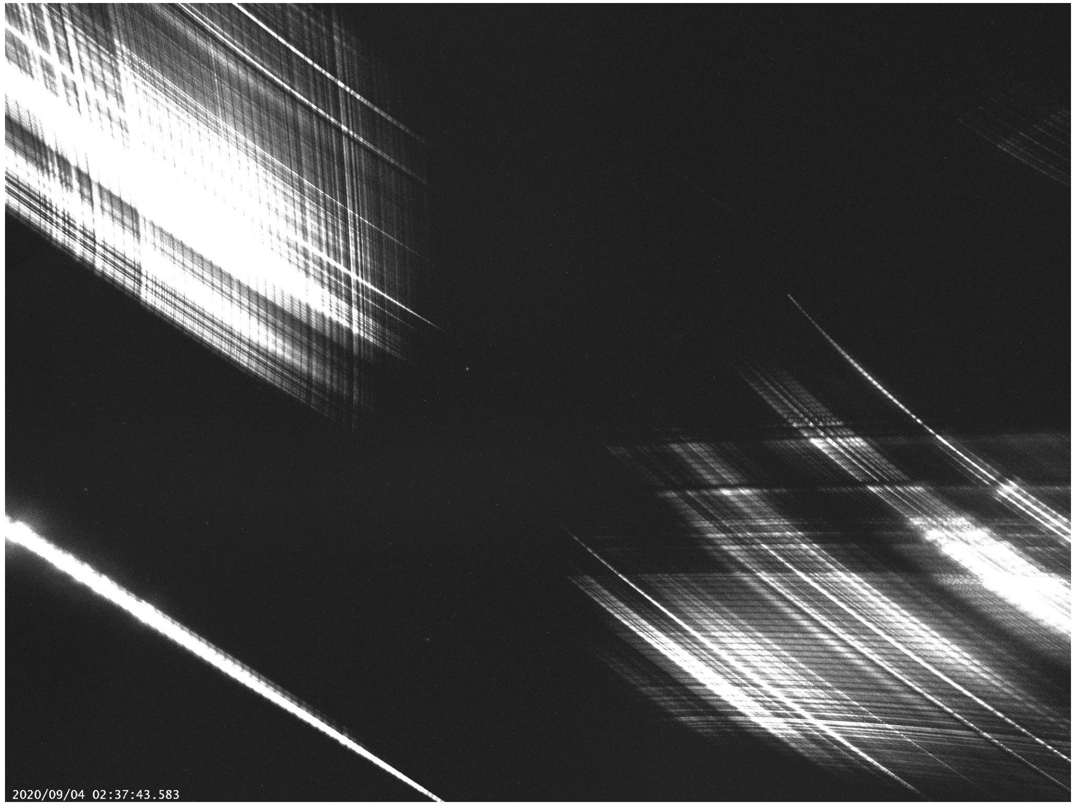




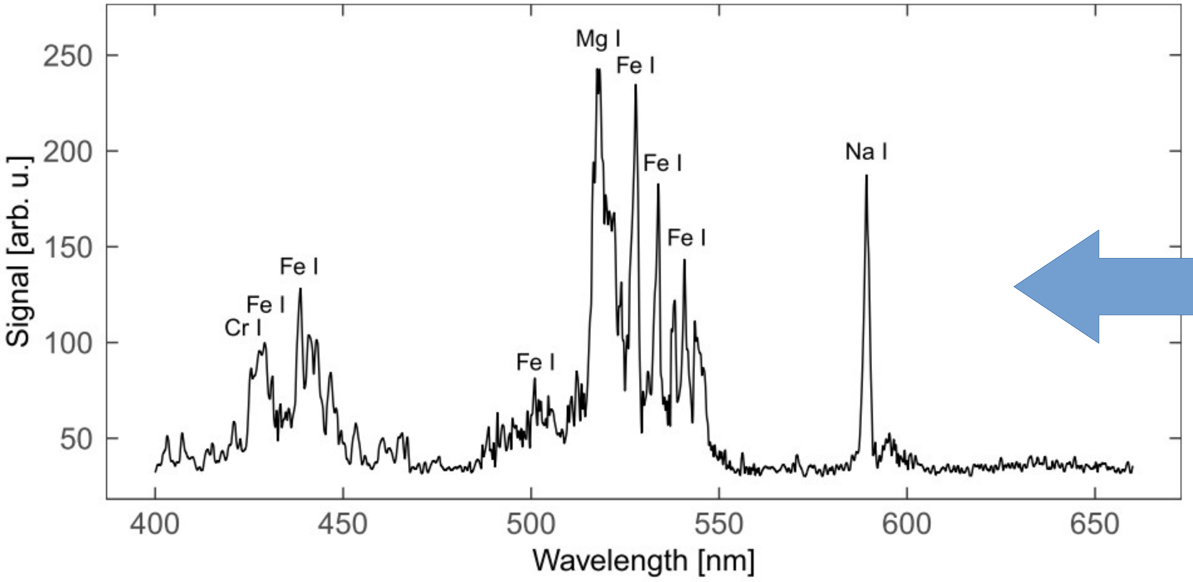
Property	Value
Shape and size	Round, 40 mm in diameter
Field of view	60°
Structure	2 halves, same size
Line density	800 l/mm
Spectral range	400 – 900 nm
Peak diffraction efficiency	80%

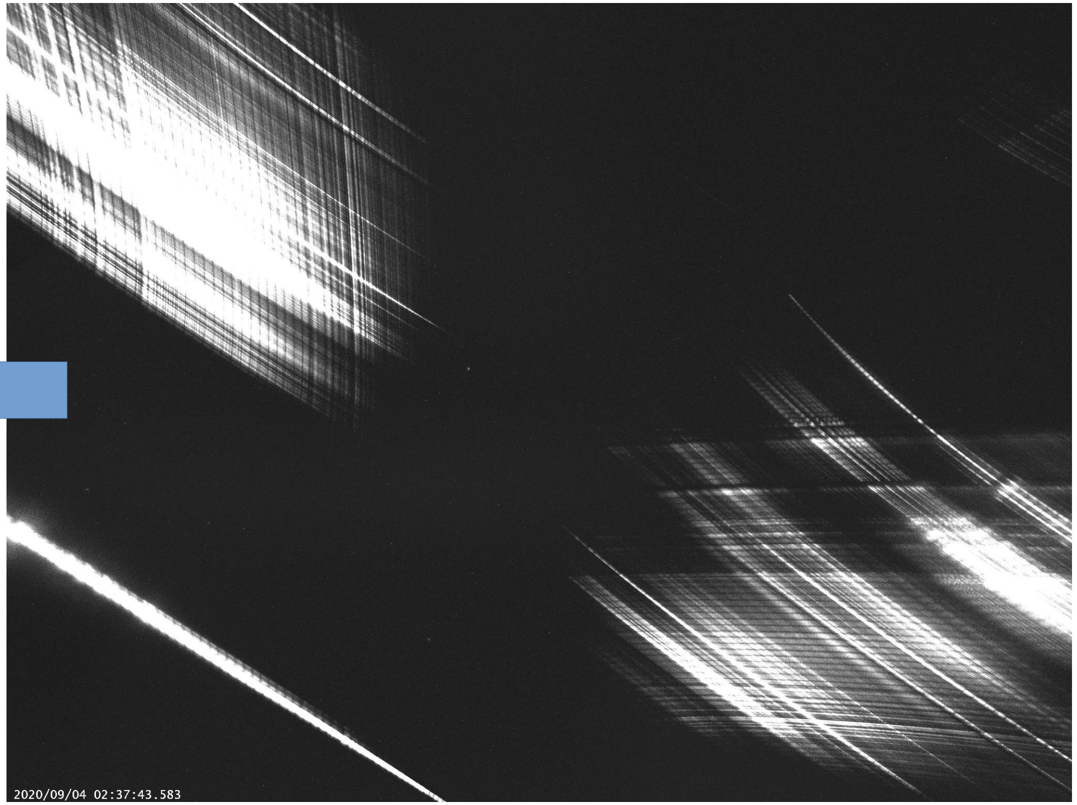
Overcoming the direction uncertainty





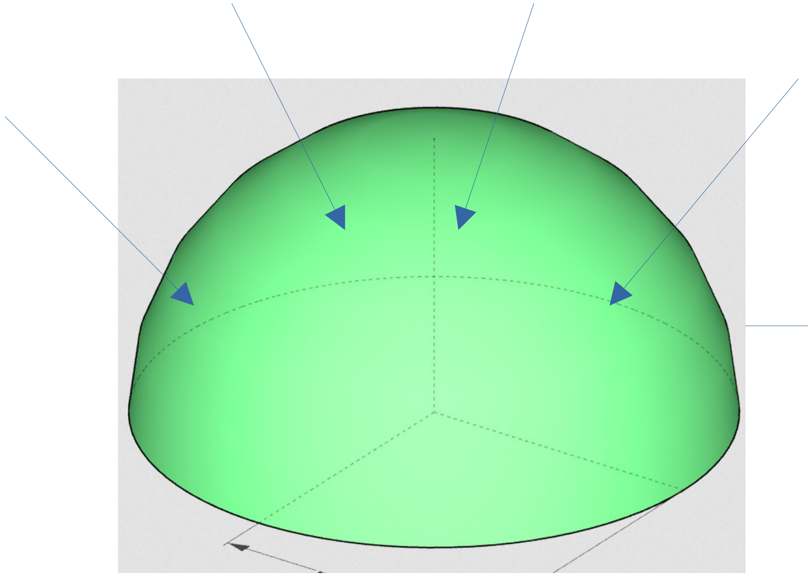
Overcoming the direction uncertainty





Other possibilities

- A flat grating can be a limit if the FoV is very wide;
- Curved "VPHGs": apply the grating on the hemisphere;
- Necessary to model the system and the response.



Conclusions

- VPHGs are useful dispersing elements for astronomical spectrographs;
- We can produce them in a wide range of parameters exploiting a flexible proces;
- They are suitable for the spectroscopic upgrade of PRISMA camera;
- Know-how developed with the AMOS cameras;
- Some ideas vs some issues.

Thanks...

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