

# Colors of the universe – market study on optical filters for professional astronomy

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For astronomers, filters are essential observational tools and in many cases, it is hard for them to find the best supplier. We present list of filters manufacturers and their capabilities sorted and discussed.

## 1 Introduction

Astronomy as today relies on ground and space telescopes as main mean of study of the universe. Telescopes are designed for obtaining information about various objects differing in nature and therefore by emitted or reflected light incoming to Earth. Telescopes are very complex machines containing precise optics to acquire as much light as possible. Equally important are other parts of system, mount of telescope, adaptive system driving optics to ideal shape and of course detector. Nowadays common goal for telescopes are all-sky surveys where large detector in even larger mosaic are used. This put difficult demand on optic design and quality. It also affects demand on next key part of the system - filters. Filters are essential for obtaining information about spectral properties of observed objects as detector can by nature only capture intensity insight of its spectral range. To manufacture precise filters is equally demanding like optics of telescopes because of many necessary technics during manufacturing (polishing, coating, mounting ...)

## 2 Filters

Historically well-defined color glass filters have been used by astronomers. Nowadays interference filters with thin-film optical coatings become more popular. These are often more expensive because of technological difficulties, but allow flexibility to create very broad or very narrow filter bands. In both cases production of large filter dimensions is demanding and only a few specialized manufacturers are capable to create such filters for professional astronomical telescopes. [1]

Astronomical filters can be also divided by band width. In astronomy, many various narrow band filters are used for imaging of specific lines of gases like SII, OIII or H $\alpha$ . Width of these filters is in order of single nanometers. Also, broad band filters have been designed for study of specific spectral properties of stellar objects. Often these broad band filters form whole filter sets which cover whole spectrum

from near UV trough visible light to near IR according to atmospheric opacity like Fig. 1 shows.

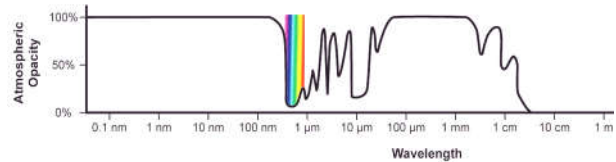


Fig. 1 Spectral dependence of atmospheric opacity.

As main representatives are Johnson-Cousins or Sloan filter systems. First used for photon multiplier detector hence unusual shapes of bands on Fig. 2. It is widely used till today because of historical continuity. More modern Sloan filter system is accustomed for CCD detectors on Fig. 3 spectral characteristics with CCD detector sensitivity is multiplied and shown.[1]

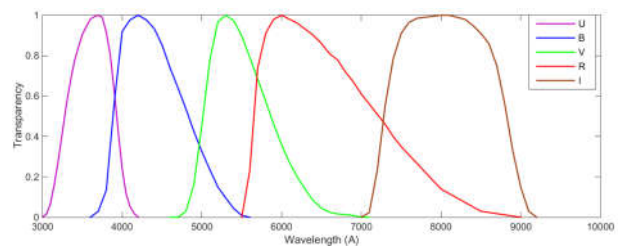


Fig. 2 Spectral characteristic of Johnson - Cousins filter system.

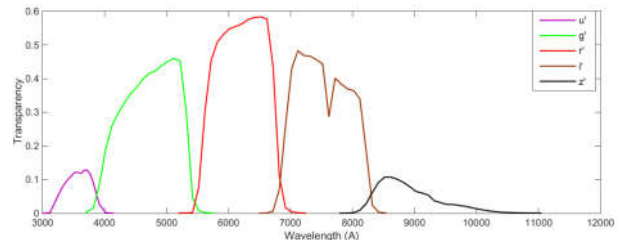


Fig. 3 Spectral characteristic of Sloan filter system.

### 3 Manufacturers

It is obvious that filters have many different demands hence manufacturers had to choose which can be produced and only the largest can meet the strictest. One of the most excluding is filter size. Common filter sizes are around 2 inches up to 70mm. More demanding telescopes need filters up to 2000mm but there are some of the projects that requires 600mm or even bigger. [2]

We can divide manufacturers by technological steps that can complete within his company for example:

- a) Filter glass malting
- b) Polishing
- c) Dielectric coating
- d) Gluing of filters
- e) Mounting of filters
- f) Environmental testing of filters

Not all manufacturers are focused on all steps of production.

Manufacturer	Country
Schott	Germany
Optics Balzers	Liechtenstein
LZOS	Russia
Asahi Spectra	Japan / USA
Safran-Reosc	France
CILAS	France
Nantong Yinxing Optical	China
Hoya	Japan
Potapenko Glass & Filters	Ukraine
Materion	USA
VIAVI Solutions	USA
SEMROCK	USA
Sodern	France
Salex Galileo	Italy
Iridian Spectral Technologies	Canada
Toptec	Czechia
Astronomik	Germany
Lumicon	USA
Spectrogon	Sweden

**Tab. 1** List of astronomical filters manufacturers

In Tab.1 there are manufacturers that are active in field of astronomical filters production. It is clear, that market is evenly spaced between all parts of the world. To evade the need for huge filters, manufacturers tends to cut them in to smaller mosaics if wide field mosaic detectors are used. This trend can be beneficial for smaller manufacturers. [2,3]

### 4 Conclusion

Astronomic filters are growing bigger, trend is to use smaller filters for each detector where possible. With focus on widefield sky surveys of distant galaxies large filter sets (up to 70 filters) are required. Market with filters is scattered through world and list will likely grow.

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### References

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