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Original Research Paper

Comparison of Deviations of Various Wavelengths By Grating and Prism

Physics

KEYWORDS : Metal-ligand complexes, Substituted dihydropyrimidin-2(1H)-one, Stability constant and Job's method of continuous variation.

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ABSTRACT

Comparative study of deviations due to prism and grating is done here. Ordinary prism and 15000 LPI grating is used to observe white light spectrum. Our results show that the grating is much better in resolving white light into its constituent colours. However, when we compare resolution with difference in wavelength, we find that it varies with wavelength in both cases. But for prism the resolution increases steadily with increasing wavelength. Whereas in grating it doesn't change much even at higher wavelengths. Besides, the resolution for prism is four times higher than in grating for red wavelength. This matches with the general conclusion the prism is performing better at near Infra red region. At the same time grating gives more deviation of spectral lines as compared to deviations in prism.

Introduction:

Spectroscopy involves the use of some dispersive element (a prism or diffraction grating) to spread light out in wavelength so that we can examine and analyse the flux distribution as a function of wavelength or frequency. The simplest form of astronomical spectroscopy is the objective prism.

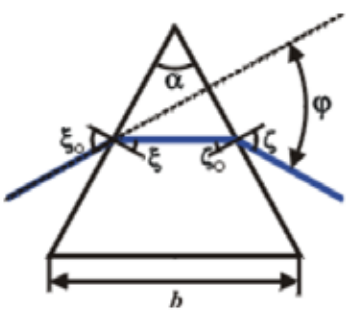

Figure 1: Schematic of Prism

Diffraction gratings have been in use in astronomical spectroscopy for many decades. These have typically been of the transmission or surface reflecting (SR) types and generally consist of parallel lines "ruled" on a reflecting surface or small "steps" on a reflecting or transmitting surface. Nowadays, gratings are often produced by photolithographic etching, electron-beam etching and other methods which give higher accuracy than the classical "ruling" methods.

Sometimes a diffraction grating is used in place of the prism for studying optical spectra. A prism refracts the light into a single spectrum, whereas the diffraction grating divides the available light into several spectra. Because of this, slit images formed using a prism are generally brighter than those formed using a grating. Spectral lines that are too dim to be seen with a grating can often be seen using a prism.

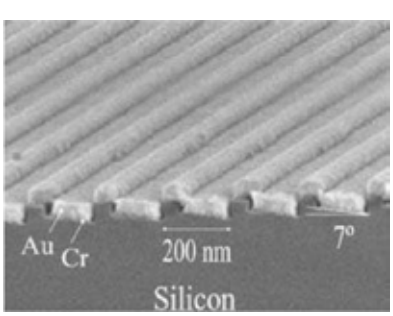

Figure 2: Micro photograph of Grating made up of Silicon

Comparative values for prism and grating is shown in below table.

Characteristics	Prism	Grating
Spectral resolution	1 - 10 nm variable	1 - 10 nm constant
Wavelength range	365 -920+ nm	One octave: eg 400 - 800 nm
Light throughput	>60% 365-450 nm >90% 450-1000 nm	Max of ~60% at one wavelength only Above 750 nm 1-10%
2nd order pollution	None	Yes: >octave 2nd order filters are required
NIR efficiency	Excellent	Above ~750 nm very poor to mediocre

Theory and Experiment:

The light to be examined is rendered parallel by a collimator consisting of a tube with a slit of adjustable width at one end and a convex lens at the other. The collimator has to be focused by adjusting the position of the slit until it is at the focal point of the lens. The parallel beam of light from the collimator passes through a glass prism standing on a prism-table which can be rotated, raised or lowered, and levelled. The prism deviates the component colors of the emitted light by different amounts and the spectrum so produced is examined by means of a telescope, which is mounted on a rotating arm and moves over a divided angular scale. The theory of the prism spectrometer indicates that a spectrum of maximum definition is obtained when the angular deviation of a light ray passing through the prism is a minimum. Under such conditions it can be shown that the ray passes through the prism symmetrically. For a given wavelength of light traversing a given prism, there is a characteristic angle of incidence for which the angle of deviation is a minimum. This angle depends only on the index of refraction of the prism and the angle between the two sides of the prism traversed by the light.

The amount by which the visible spectrum spreads out into its constituent colors depends on how rapidly the refractive index of the prism material varies with the wavelength of the radiation.

A Laboratory spectrometer is used to measure the angular deviation for various wavelengths. Mercury light as a source is used to illuminate the slit. Spectrometer is set up using shuster's method for parallel rays. A spectrum is obtained using Extra Dense Prism of refractive index 1.6 and is set to minimum deviation position. Observations for different colours are noted as shown in Table 1. Angles of minimum deviations is calculated for all the colours. Simi-

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larly 15000 Lines per Inch Grating is used to obtain the spectrum and observations for first order spectrum lines were noted as shown in Table 2. Comparison between the two methods of studying spectrum of white light is made as described below.

Analysis:
In Table 1 and 2 are shown the observations of spectral lines for Prism and Grating respectively. Each observations is deducted from straight reading to obtain the angle of minimum deviations. To measure the spacing between the colours of the spectrum difference between readings of red (first) and violet (last) colours have been taken.

Prisms can spread light spectra into many colors for analysis. This is often good enough. A diffraction grating does very much the same thing. However, a diffraction grating is less sensitive to the color of the light and can be made to spread colors over a larger angle than a prism. The glass in a prism is clear to visible light, but it absorbs and blocks light in the infrared and ultraviolet part of the spectrum. Chemical analysis often depends on identifying particular colors from the spectrum of the sample which are beyond the visible range.

The angle of the first-order deflection (θ) can be described in terms of the distance between lines (d) and the wavelength (λ). $\tan(\theta)=\lambda/d$. A diffraction grating with a few hundred lines per inch can deflect light in the middle of the visible spectrum by at least 20 degrees. Figure 3 shows a plot of spectral resolution against wavelength for prism whereas figure 4 is a plot for spectral resolution against wavelength for grating. It can be observed that in figure 3, the resolution increases with wavelength and gets maximum for red which is closer to the near infrared region. However, in grating the resolution doesn't change much with increasing wavelengths. The resolution using prism in red wavelength is as good as four times higher than the resolution using grating.

Table 1: Observations for deviations for various colours using Prism

Colour	Wavelength in Angstrom	Spectrometer Readings for Minimum Deviation	Straight Reading	Minimum Deviation Angle	Angle Between Red and Violet	tan
Red	6800	78°33"		50°43"		3333.333
Yellow	5800	78°15"		51°01"		1578.947
Green	5200	77°52"	129°16"	51°24"	04°05"	213.6752
Blue	4700	75°32"		53°44"		571.4286
violet	4100	74°28"		54°48"		

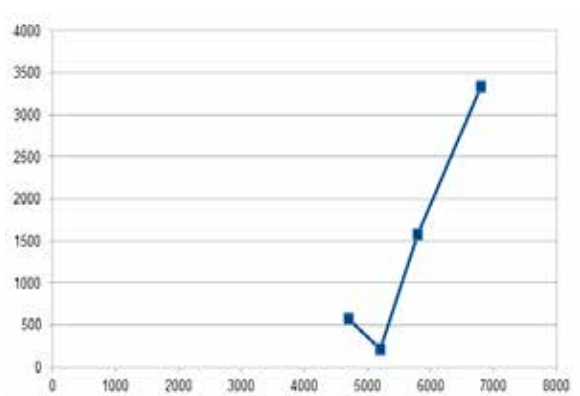

Figure 3: Graph of resolution with increasing wavelength for Prism

Table 2: Observations for deviations for various colours using Grating

Colour	Wavelength in Angstrom	Spectrometer Readings for First Order	Straight Reading	Minimum Deviation Angle	Angle Between Red and Violet	tan
Red	6800	110°48"		17°42"		333.3333
Yellow	5800	112°00"		16°30"		659.3407
Green	5200	112°55"	128°30"	15°35"	06°12"	156.7398
Blue	4700	116°06"		12°24"		566.6667
violet	4100	117°00"		11°30"		

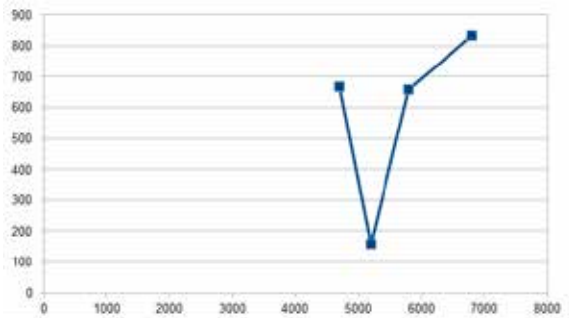

Figure 4: Graph of resolution with increasing wavelength for Grating

Results and Discussion:
We have carefully analysed and compared observation obtained for prism and grating for various wavelengths. The graphical results are shown in figure 3 and 3. The spacing between the red and the violet wavelengths in grating is greater than that for the prism. We have shown that the resolving power of grating is much better than that of prism in general.

However, when we compare resolution with difference in wavelength, we find that it varies with wavelength in both cases. But for prism the resolution increases steadily with increasing wavelength. Whereas in grating it doesn't change much even at higher wavelengths. Besides, the resolution for prism is four times higher than in grating for red wavelength. This matches with the general conclusion the prism is performing better at near Infra red region. At the same time grating gives more deviation of spectral lines as compared to deviations in prism.

References:

1. J. Strong, Resolving power limitations of grating and prism spectrometers journal of the Optical Society of America 39(4):320-3, May 1949.
2. Images for Figure 1 and 2 is taken from *www.star.ac.za/sites/default/files/downloads/spec1.pdf.*