MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Physics Department

Physics: 8.03 Spring 2003

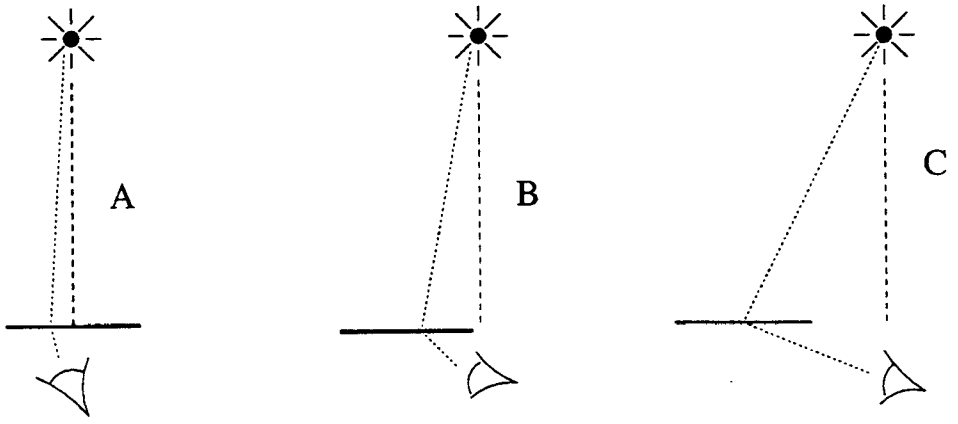
Take-Home Experiment #9

TRANSMISSION GRATING

Objective In this experiment you will explore both the behavior of an optical transmission grating and the nature of various light sources.

Experiments When using a transmission grating, light which is incident at a specific angle on one side of the grating is deflected by different angles on the other side depending on its frequency. If the incident light is coming from an extended source, then there is a distribution of incident angles. In order to resolve clearly two different lines in the source, the angular width of the source seen from the grating must be smaller than the difference in the angles by which the two lines are deflected. Thus, to obtain high resolution, one must use a source with narrow angular extent. A frosted 60 watt light bulb across a dorm room is not so good. A street light several blocks away is better. The filament of the mini-maglite viewed on edge is quite good.

The Grating Set up the mini-maglite as you did in the experiment on diffraction. Hold the grating close to your eye (with its plane perpendicular to the line of sight) and view the resulting spectra. Refer to figure A. You should see the 0^{th} order image (no dispersion) straight ahead and two 1^{st} order spectra (modest dispersion) displaced about 20 degrees to the left and right. You will find that you can view the 1^{st} order spectra more easily if you translate the grating sideways so that the colored streak is centered in the slide frame and your new line of sight is 20 degrees to one side of the source (see figure B). By translating the grating further way from the line between you to the source (figure C) you should see the two 2^{nd} order spectra (more dispersion but weaker), one on each side. Can you find 3^{rd} order spectra?



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Bring the grating back into line with the source and close to your eye so that you can see the 0^{th} and 1^{st} order spectra at the same time. What happens when you rotate the grating about the line of sight? What happens when you tilt the grating relative to the line of sight? Is the light in the 1^{st} order spectra polarized? You would get a different result for the polarization if the spectra were generated by a metallic grating. Why do you think this might be the case?

Continuous Spectra Examine the spectrum of the mini-maglite. Notice that it has a smooth distribution of intensity throughout the range of colors that are visible. There are no sharp features which would indicate radiation from isolated atomic transitions. This is characteristic of incandescent sources, that is, those generated by heating a filament. Now that you know there are no lines to be missed by a smearing of the spectrum in angle, you may want to look at an ordinary light bulb with the grating. The spectrum will be taller now and the colors easier to appreciate. Examine the transmission characteristics of the colored filters by moving them in and out of your view of the spectrum. With the taller spectral image you could even have the top half unobscured while the filter covers the bottom half.

Spectra with Atomic Lines The best place to find line spectra is on the street at night. Look at the mercury vapor type of street lights (blue-green), the sodium vapor street lights (yellow) and the neon signs ("Buy Our Beer!"). These sources should consist of several prominent lines (characteristic of the atoms in the discharge or hot vapor) in addition to a continuous part. Back inside, find a fluorescent light. A fluorescent desk lamp is ideal. Make a cardboard mask with a thin slit cut into it. Tape the mask in front of the bulb. Explore the contention (made in the Thin Film Interference experiments) that there are several sharp lines in the spectrum. Do any of them occur as pairs?

Other Sources Exercise your curiosity. Examine the spectra of other sources. Small neon bulbs are sometimes used as pilot lights in inexpensive electrical appliances such as plug strips and surge protectors. What about the flame from a candle, a gas burner? You could try seeding the flame with a chemical such as salt (sodium chloride). Remember the flame tests from chemistry lab?