Transparent Diffraction Grating Interferometers

Kevin R. River
laserlightnow@gmail.com

June 8, 2020

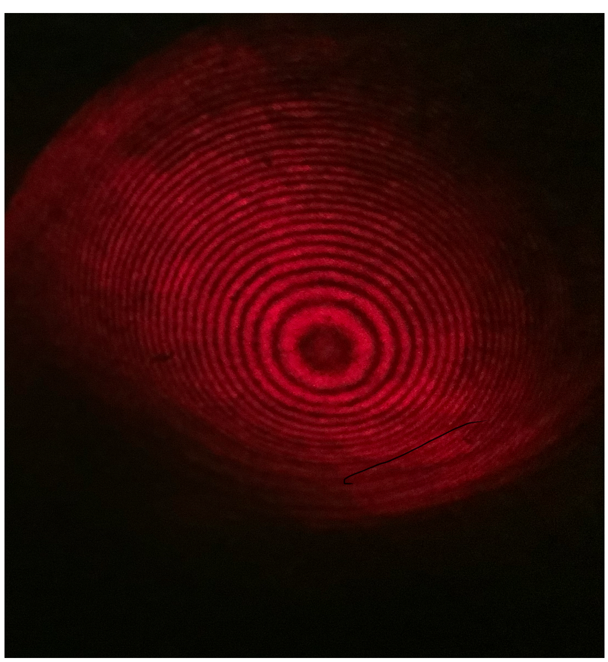
Abstract:
This paper will present three interferometer designs that use transparent diffraction gratings to create light paths that cause coherent light to produce interference patterns.

Introduction: Over the past month I have been creating and testing interferometer designs that use transparent diffraction gratings as the main method of creating light paths for interferometers. I was able to create dozens of designs that produced interference patterns. It was surprising to learn that there was no evidence online that any of these designs had been used. There were no diagrams, photos, or articles that discussed the kinds of interferometers I was creating. Because of this, I have decided to post on this site the three most promising designs I have created. Maybe someone will see them and use them as a starting point of a worth while project. Because these are new, they have no names or descriptions. I will name each interferometer according to its characteristics along with a light path diagram and an account of my experiences working with them.

The transparent diffraction gratings I used were linear holographic, the kind that can be purchased in classroom sets. I experimented using different lines/mm and found the 500 lines/mm produced best interference patterns. To keep these diagrams manageable, only the zeroth order (center beam) and the first order (outside beams) from the diffraction grating will be discussed and shown in the diagrams.

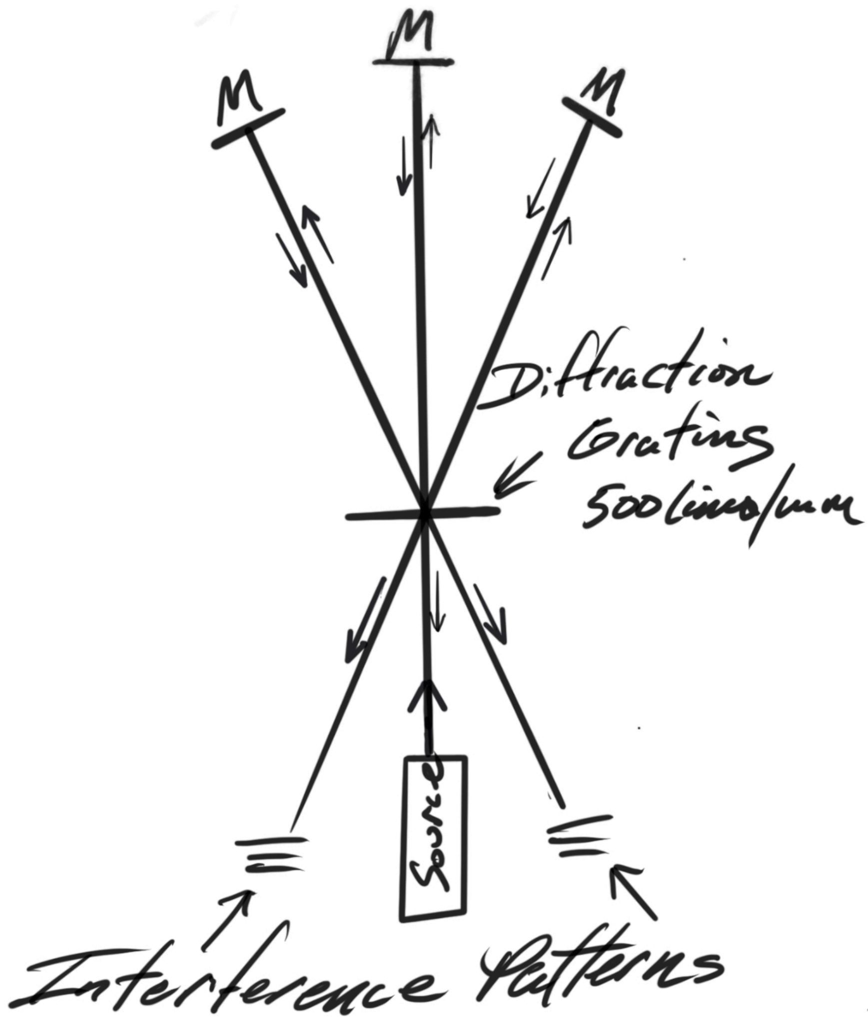
The coherent light source I used was a 650nm 3.5mW laser diode. The mirrors were all optical quality first surface. They will be identified with the letter M in the diagrams. In some designs a beam splitter was use. It will be labeled B/S. Soon after this publication I plan to post a video that demonstrates these interferometers. The YouTube channel is: Beyond Interference

The image below is typical of the interference patterns created by the interferometers shown in this paper. This particular image was taken from interferometer #2.



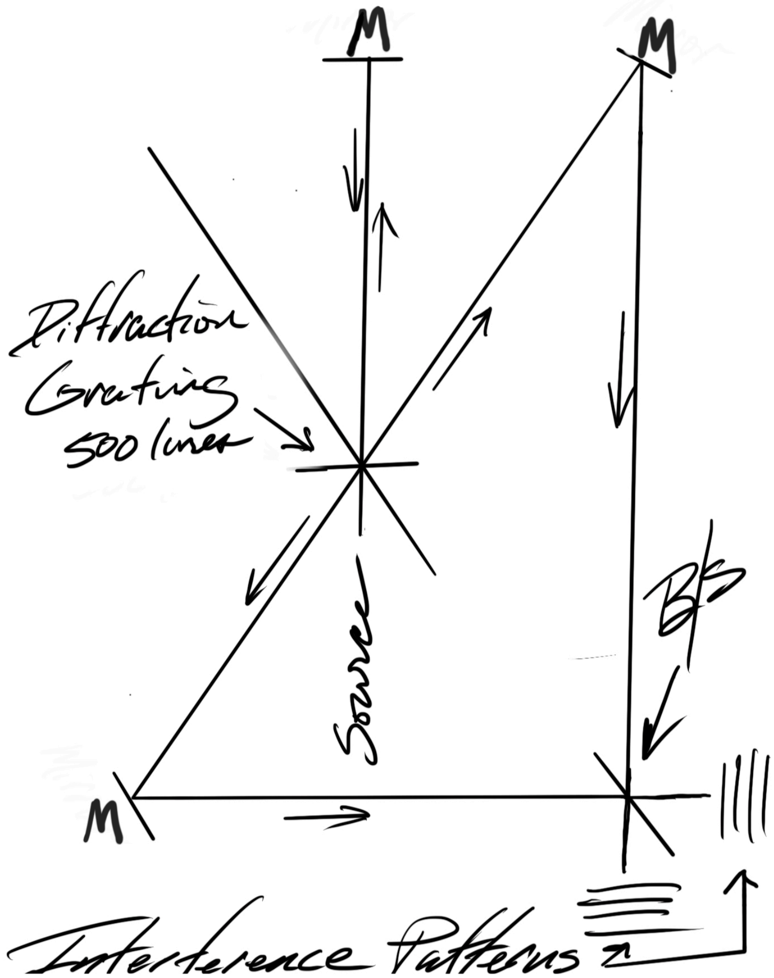
#1

Shared Path Interferometer



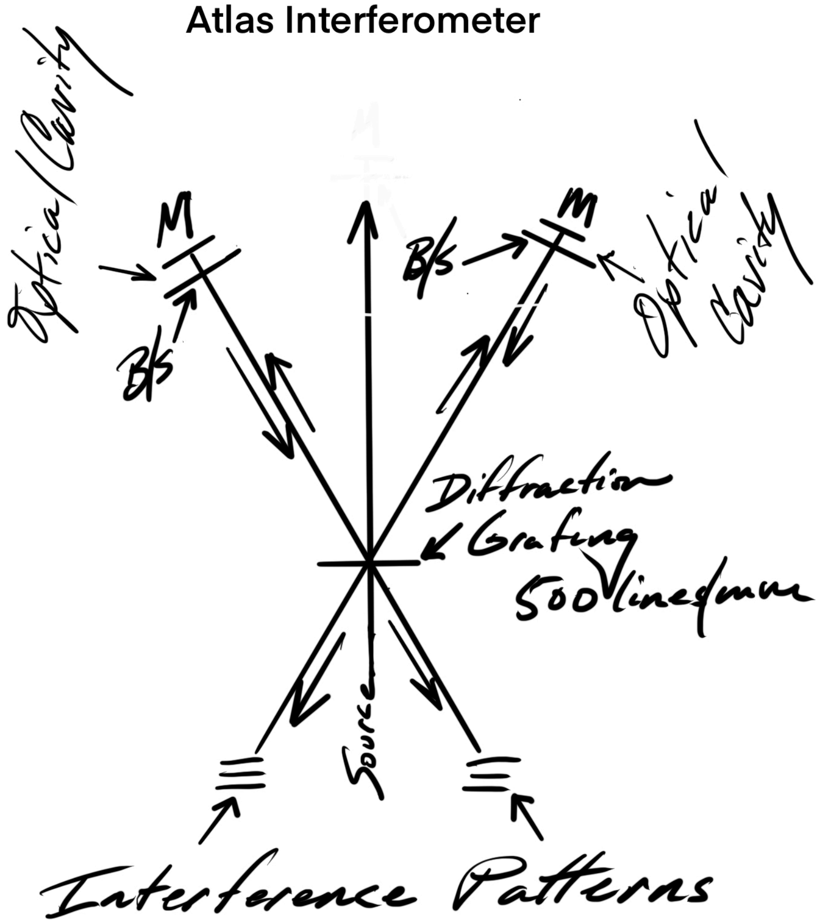
This interferometer produces clear bright easy to obtain interference patterns. It is best described as two independent interferometers that share a common path. When coherent light passes through the grating it is divided into three separate paths. After reflection off the mirrors, the beams are sent through the grating in the opposite direction. The center beam dividends again. These new paths interfere with the returning light from the outside mirrors.This produces clear bright interference. Thus we have two interferometers that are independent of each other but share a common path. Movement of the center path affects both patterns, but movement of an outside path does not affect the other outside path. This may have applications for comparison measurements due to the fact that one pattern could sever as a control while the other performs a test.

#2
π Interferometer



This interferometer starts with light traveling in opposite directions,180 degrees or pi, and the complete light path creates a triangle shape which one could argue is the shape of a piece of pie. It's similar to a Sagnac but the paths don't overlap; they are separate. This has the advantage of allowing the user to create differences between the two path lengths which give the user more control over the size and shape of the interference pattern. It is sensitive to rotation and may have applications in rotating platforms. The fringes it produces are clear and bright. Alignment is easy. Only the zeroth order and one of the first order beams from the diffraction grating are used. The selection of which first order beam to use is arbitrary.

#3
Atlas Interferometer



This interferometer is simple and produces impressive interference patterns. The name is derived from the fact that one diffraction grating is capable of “holding” many optical cavities. With a little imagination you can also see, in the diagram, a figure holding something over its head. Unlike a Fabry-Perot etalon this interferometer uses a first surface mirror at one end of the optical cavity. This is similar to a Gires-Tournois interferometer, but what makes the Atlas different is that it allows several independent cavities to use one light source simultaneously. This allows the user to compare the two patterns and determine if a cavity is affecting the pattern or if the light source is affecting the pattern. The diagram above shows two optical cavities, one for each first order beam. However, a cavity may also be placed on the zeroth order beam. This will produce two new interference patterns, but unlike the first order interference patterns, which act independently, these two patterns will be locked together.