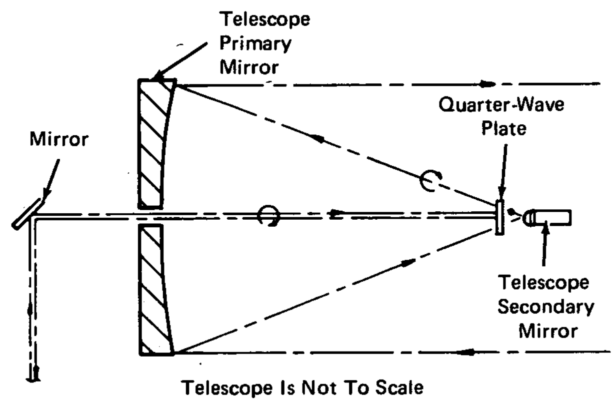
NASA TECH BRIEF

Marshall Space Flight Center

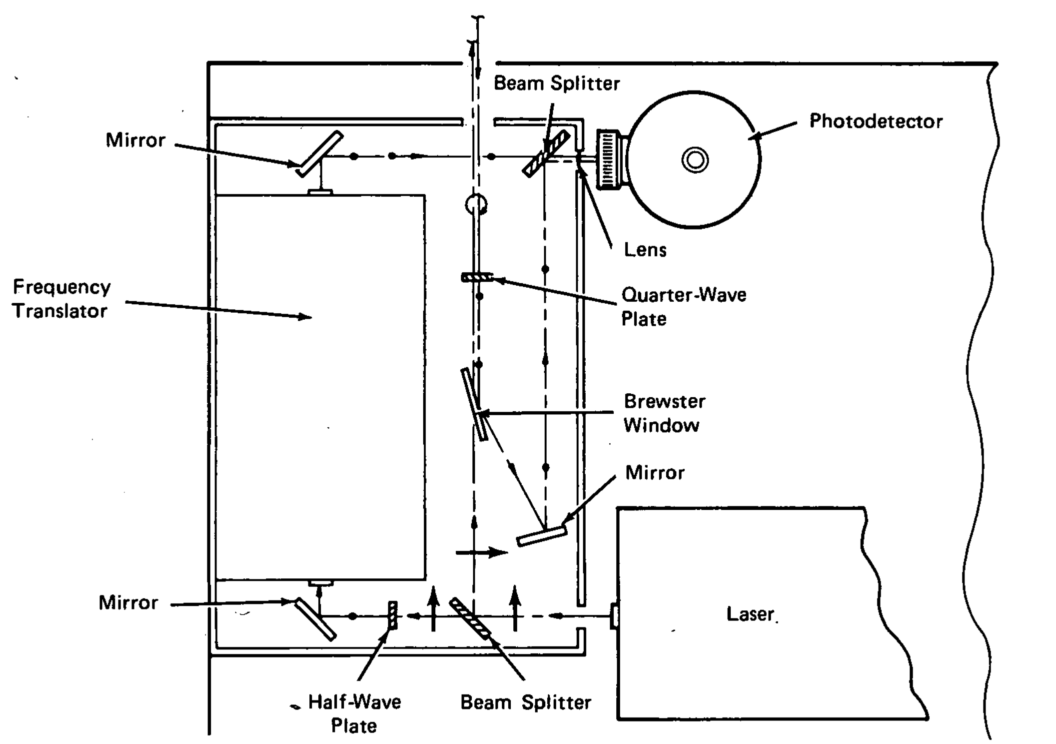
Mach-Zehnder Optical Configuration With Brewster Window and Two Quarter-Wave Plates

Laser-Doppler velocimeters are used for remote measurements of atmospheric winds and wind-shear profiles, and for remote velocity sensing of many gas, solid, or liquid flows. For optimum performance, velocimeters require an optical system which:

1. isolates the system performance from the laser-cavity gain and its limited frequency response;
2. does not reduce the efficiency of a frequency translator, by introducing additional frequency components which result in ambiguous measurements; and
3. has minimum regard to losses due to the optical elements and their configuration.



Telescope Is Not To Scale



A Quarter-Wave Mach-Zehnder Configuration For Use With Translator With Less Than 15 Percent Efficiency

(continued overleaf)

A Mach-Zehnder optical configuration is used to meet these requirements. The principle of its operation is illustrated in the figure. A horizontally polarized (>99:1 polarization ratio) beam emerging from the laser strikes a beam splitter, 95 percent of which is incident on the Brewster window. The beam polarization is such that the beam is transmitted through this window with an efficiency of 99 percent. Next, it passes through two CdS quarter-wave plates and is converted to circular polarization by one, then back to vertical polarization by the other plate. A portion of the reflection off the telescope secondary mirror returns through both quarter-wave plates, converting the beam back to horizontal polarization. This direct feedback passes through the Brewster window with 99 percent efficiency.

The remainder of the output beam, expanded through the quarter-wave plate, strikes the primary mirror and is transmitted to the focal volume circularly polarized.

Light scattered by particles, which is changed only in the sense of circular polarization, is collected by the telescope and then transmitted through the two quarter-wave plates; it passes from circular to horizontal, to circular, and then to vertical polarization at the Brewster window. The light is predominantly reflected by the Brewster window and eventually combined with the local oscillator beam at the beam splitter before the photodetector.

The 5 percent of the initial beam which passes through the beam splitter before the laser, and through a half-wave plate, is rotated to a vertical polarization. It then passes through the frequency translator where it is shifted, to provide a frequency offset to determine the sense of the Doppler signal. After combining with the return signal, the beams are photomixed on the photodetector.

This configuration is an improvement over other interferometers because of the following:

1. It provides higher efficiency. Losses due to optical elements are less than in other Mach-Zehnder configurations. There is an improvement of over 6 dB in signal-to-noise ratio over the 50-50 beam splitter arrangement.
2. The configuration reduces or eliminates feedthrough of the untranslated local oscillator, which would produce a beat signal at the shifted frequency of a translator.
3. When used without a translator and with a low-power detector, the telescope secondary mirror reflects a portion of the output to a local oscillator. The oscillator is aligned automatically with the signal return.

Note:

Requests for further information may be directed to:
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Patent status:

NASA has decided not to apply for a patent.

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