NASA TECH BRIEF
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Interferometric Measurement of the Velocity of Radiating Particles

An electro-optical system measures very small Doppler-shift displacement of the spectral wavelengths emitted by atoms and ions in a high-velocity plasma beam. The system (see figure) is capable of detecting shifts as small as 0.002Å in the wavelengths of visible spectral lines (4000-7000Å). This corresponds to detecting a 1% change (about 10^4 cm/sec) in the velocity of a light-emitting beam that characteristically moves with a velocity of about 10^6 cm/sec.

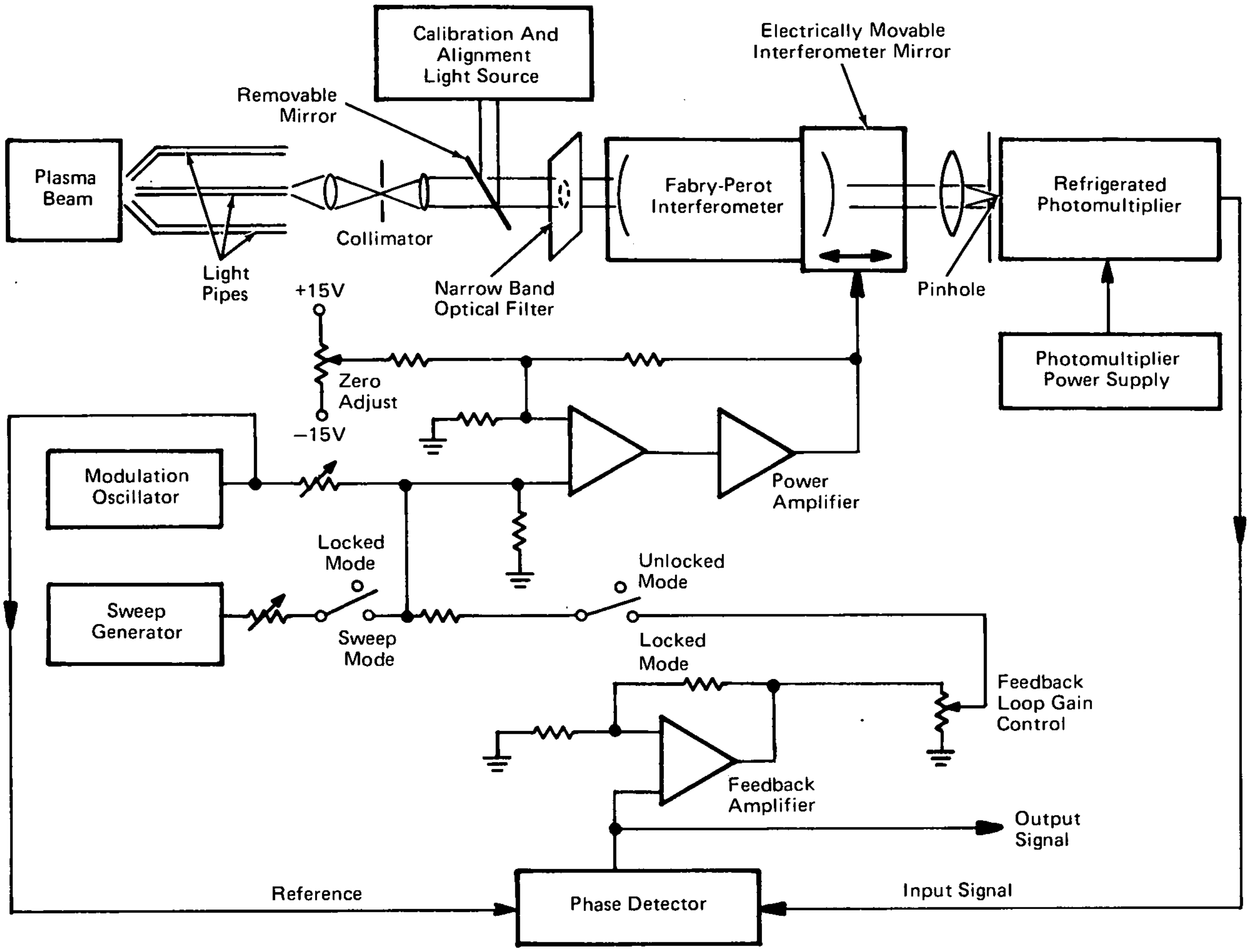
The system is essentially a servo-controlled Fabry-Perot interferometer. Three fiber-optic bundles (light pipes) are used to collect light emitted from the plasma beam in different directions. One pipe is aimed in a direction perpendicular to the plasma velocity, so that the collected light bears no Doppler shift. The other two pipes are inclined ahead and behind the perpendicular, so that the collected light bears Doppler shifts toward shorter and longer wavelengths, respectively. The light from one pipe at a time is fed through a collimator to a narrow-band optical filter, which is selected to pass one particular wavelength of the spectrum of the atomic or ionic species under study.

The output of the filter then goes to the Fabry-Perot interferometer, which is composed of two curved partial reflectors operated in the confocal mode. The interferometer produces a transmission pattern of concentric rings which is very strongly wavelength dependent. The central ring of the pattern is imaged through a pinhold onto a very sensitive photomultiplier, which is refrigerated to minimize dark current and Johnson noise. The photomultiplier converts any change in the intensity of the central ring into a corresponding change in an electrical signal.

Two factors affect the intensity. One is the wavelength shift which is to be measured; the other is an overall change in the light intensity emitted by the plasma. To reduce this error-causing sensitivity to input signal amplitude, a sophisticated modulation and phase-detection system is used. A signal from a modulation oscillator is used to sweep the interferometer adjustment periodically across the desired wavelength band. The fluctuating output of the photomultiplier is then fed to a phase detector, together with a reference signal from the modulation oscillator. The detector operates in the quadrature mode, producing a null output when the center of the Fabry-Perot resonance corresponds to the center of the spectral line. Deviations of the line toward shorter or longer wavelengths produce opposite-polarity error signals from the detector. These signals provide the system output and are coupled through a feedback loop. When the interferometer is operated in the locked mode, the feedback signal is added to the modulation signal and applied to the electrically movable (either magnetic or piezoelectric drive) mirror. The feedback readjusts the central position of the mirror to reduce the error voltage.

To align and calibrate the interferometer, it is convenient to use a laser beam. This is applied at the input by introducing the removable mirror shown. For calibration purposes, the system is operated in the unlocked sweep mode. A low-frequency linear sawtooth from a sweep generator causes the interferometer to scan slowly across the desired wavelength band. The output signal voltage is then recorded as a function of wavelength. This technique may also be used to measure the width and shape of an observed spectral line. The output signal

(continued overleaf)



voltage directly corresponds to the derivative of the line shape with respect to wavelength. Numerical or analog integration yields the actual line shape.

Note:

No additional documentation is available. Specific questions, however, may be directed to:

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No patent action is contemplated by NASA.

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