CC/NUMBER 37
SEPTEMBER 15, 1986

This Week's Citation Classic®

Howard R & Harvey J. Spectroscopic determinations of solar rotation.
Solar Phys. **12**:23-51, 1970.
[Hale Observatories, Carnegie Institution of Washington, California Institute of Technology, Pasadena, CA]

Photoelectric spectral line-shift data obtained from full-disk solar scans at the Mount Wilson Observatory were analyzed for differential rotation of the sun. The plasma rotation rate was found to be about 5 percent slower than the sunspot rotation rate and somewhat variable in time. [The *SCI*® indicates that this paper has been cited in over 170 publications.]

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August 22, 1986

In the mid-1960s advances in digitization and digital control circuits made possible a quantum jump in the quality and quantity of observational data in solar astronomy that could be recorded and analyzed. At Mount Wilson, we were among the first to take advantage of these new opportunities, and the benefits of the new techniques surprised even us. Jack Harvey was a graduate student at the time this paper was written. He worked one summer (1965) on the project and contributed significantly to the overall effort.

Up to the time of this paper, spectroscopic determinations of solar rotation had been accomplished photographically by placing the spectrograph entrance slit at the east and west limbs of the sun to make separate exposures for measuring the Doppler effect. This technique led to a whole host of problems in measurement and interpretation. To begin with, there were the usual errors to be expected in determining the accurate position of a spectral line on a photographic emulsion. But more important than that were the errors that resulted from velocity fields on the sun. With only a handful of points measured, the supergranular and granular velocity fields can have a very serious effect on the measured Doppler shift. In addition, the Evershed effect and other motions associated with active regions and possibly with lower-amplitude flows resulting from giant circulation patterns or meridional motions may further degrade the measurements. Furthermore, the east-west symmetry of the limb red shift has never been established to the accuracy often claimed today for rotation results, so even now photoelectric results are less certain than many authors have stated.

The principal advantages of the technique we introduced lay in the precision of individual measurements and the large number of these individual measurements—covering the solar disk—for each observation. We were thus able to average out many of the velocity field effects, but not all. In fact, several new effects were later discovered at Mount Wilson using this instrument and these techniques.

This paper has been criticized by several people,[1,2] including me,[3] for the instrumental effects that it neglected—one reason, no doubt, for its good citation rating. Among these effects are scattered photospheric light and optical fringing in the spectrograph. Actually, it was a number of years before these shortcomings became apparent.

I suppose the paper has been frequently cited mainly because it introduced a new and valuable technique in a subdiscipline, and thus it served to revive interest in this area. There have been more accurate rotation determinations published since this paper. The whole field of large-scale motions on the solar surface has benefited from theoretical advances over the past 15 years or so,[4] and this has added to the interest in the field and to the number of citations for this paper.

1. **Scherrer P H, Wilcox J M & Svalgaard L.** The rotation of the sun: observations at Stanford. *Astrophysical J.* **241**:811-19, 1980.
2. **Schröter E H.** The solar differential rotation: present status of observations. *Solar Phys.* **100**:141-69, 1985.
3. **Howard R, Boyden J E & LaBonte B J.** Solar rotation measurements at Mt. Wilson. I. Analysis and instrumental effects. *Solar Phys.* **66**:167-85, 1980.
4. **Gilman P A.** The solar dynamo: observations and theories of solar convection, global circulation, and magnetic fields. (Sturrock P A, ed.) *Physics of the sun. Volume 1: the solar interior.* Dordrecht, The Netherlands: Reidel, 1986. p. 95-160.

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