Rotation Among Solar-Type Stars

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1. Introduction

The way in which stars like the Sun spin on their axes holds the key, we believe, to understanding virtually all observed manifestations of "activity." These manifestations include the x-ray emission seen by the Einstein and Rosat satellites, far-ultraviolet atomic emission lines from the chromospheres and transition regions of stars, as observed with the International Ultraviolet Explorer and the Hubble Space Telescope, and various spectroscopic signatures observed from the ground.

Our paradigm for describing this is that rotation interacts with convection in the outer parts of a star like the Sun, and the complex circulation that results leads to amplification of the magnetic field. This field is directly responsible for the activity and spots on the stellar surface. Also, the magnetic field can grip an ionized wind (like the solar wind) beyond the star's surface, leading to angular momentum loss and the gradual spindown of the star. We can see this process happening on the Sun, and we know that solar-type stars lose angular momentum as they grow older from studying stars in clusters whose ages are known. Another key parameter in understanding the generation of magnetic fields is the degree of differential rotation in the star, a parameter known with certainty only for the Sun.

It is also possible that the rotation of solar-type stars provides a critical clue to planetary formation. This is suggested by the fact that solar-type stars that have just reached the Zero-Age Main Sequence can rotate so fast that their total angular momentum is comparable to the combined angular momentum of the Sun and planets. This may only be a tantalizing coincidence; much more must be known of rotation first.

2. FRESIP

By obtaining high-precision photometry of a large sample of solar-type stars, FRESIP will be able to provide rotation periods for each of them. Our present knowledge of rotation in stars like the Sun is limited because blatant modulation of broadband light is only seen for heavily-spotted stars (the young and active ones). Our knowledge for the older solar-type stars — especially those at least as old as the Sun itself — is incomplete and imprecise because photometric variability is too slight to be seen from the ground and the line broadening from rotation is small and difficult to analyze. However, the Sun produces a detectable photometric signature of its rotation if it is observed with sufficient precision. This arises from sunspots crossing the solar disk, and we anticipate seeing the same effect on other stars. (Indeed, seeing no evidence for spots on a star like the Sun would be revolutionary in itself.)

A subset of the FRESIP sample could also be observed for evidence of p-mode oscillations, the fruits of which can yield fundamentally-determined ages for those stars. That, in turn, will enable the detailed study of the loss of angular momentum as a function of both mass and age, which will help us understand how the Sun got to be the way it is. Recent evidence suggests that solar-type stars go through a phase in their youth in which the radiative core rotationally decouples from the convective envelope, with gradual reconnection later. Again, the combination of p-mode data with directly determined rotation periods can precisely delineate this crucial phase.

3. Conclusion

The net result is that FRESIP will produce high quality rotational data for a large (and essentially volume-limited) sample of solar-type stars. Moreover, the observed slight changes in rotation period will indicate the nature and degree of differential rotation on those stars. Both parameters are central to our understanding of the evolution of the Sun.