Plotting Stellar Surface Spotting

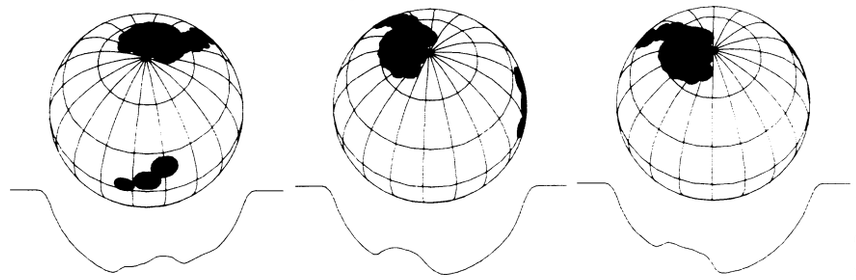
The sun is the only star close enough for us to study its surface appearance and other small details of its behavior. Astrophysicists tend to extrapolate what they know of the sun to other stars. For example, we assume other stars have sunspots, too. Steven Vogt of the University of California's Lick Observatory and graduate student Donald Penrod have developed a method for plotting and following surface features on distant stars.

Telescopes, of course, do not give images of the surfaces of stars. The most advanced techniques of speckle interferometry have managed to resolve disks of a few large nearby stars, but small surface detail is beyond visual techniques. Vogt and Penrod use computer analysis of Doppler broadening of the lines in the spectra of stars to detect and plot the changes in surface features.

A spectral line represents resonant emission or absorption, a sharp quantum energy transition of some atom that emits or absorbs light of a precise wavelength. Such a resonance appears on a spectrogram as a bright or dark line superimposed on the continuous rainbow into which a spectrogram spreads a star's light. In principle, the wavelength will be sharp and precise; in practice, motions of the source cause a spreading.

The motion that contributes most to such line broadening is rotation of the star. If the star rotates, half of its surface is always approaching us, the other half always receding. The velocities of approach and recession vary with distance from the axis of rotation—the farther from the axis, the greater the velocity. What this means spectroscopically is that the line is spread over a short stretch of wavelengths. This stretch can be subdivided and each subdivision will correspond to a particular north-south line across the disk of the star, the one with a velocity corresponding to a given amount of shift from the central wavelength.

If there are hot spots or cool spots at different locations on the disk, the scientists can detect them as bumps on a profile of the brightness across the width of the line. These bumps can be correlated with particular north-south lines on the star. If the star's rotation axis is inclined to our line of sight — most are — that gives us information about the hemisphere in which the spot is located. The computer generates models of spot shapes and locations, calculating the line profiles they would give and refines them until the profiles correspond to actuality. It is possible in this way to follow given spots around the star, and Vogt and Penrod have even made a motion picture of such changes.



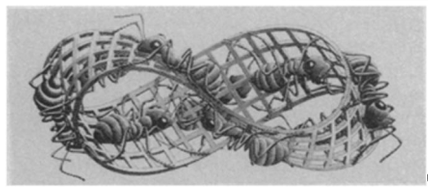
Vogt/Penrod

Spot configurations and spectral line profiles for star HR1037 in September 1981.

Because of the sizes and behavior of these features, Vogt and Penrod think they may correspond not to sunspots, but rather to the coronal holes recently discovered on the sun. Whatever the features are, the method gives a possibility of study of active surface features in swiftly rotating stars (this method works better the faster they rotate), in which the mechanisms that cause such features may be more apparent than they are on the slowly rotating sun.

The next step, Vogt says, is to study differences in polarization across the line profile to gain information about magnetic conditions. Magnetism plays an important role in the development of such surface features. —*D.E. Thomsen*

Möbius molecule: Synthesis with a twist



Escher

Take a rectangular strip of paper, twist one end 180° and attach it to the other end. The resulting one-sided surface is called a "Möbius strip" (after the 19th century mathematician who invented it). For years, the twisted strip has captured the imagination of mathematicians and illustrators. Now, some chemists have captured the figure in their laboratory.

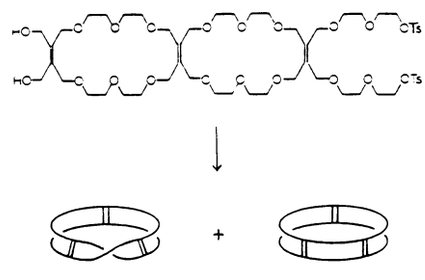
In the June 2 JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, David M. Walba and colleagues at the University of Colorado at Boulder report they have synthesized the first molecular Möbius strip. The researchers formed the figure when they joined the ends of a double-stranded strip of carbon and oxygen atoms called tris-(tetrahydroxymethylethylene) diol ditosylate (refer to the diagram). Before the twisted ring closed, the oxygens (O) and toluenesulfonyl (Ts) groups dropped off of one end of the molecule, and hydrogens (H) dropped off of the other end. This same chemical reaction yielded "cylinders"—rings with no twists.

The researchers aimed for their Möbius molecule target in part because it was "sort of a classical problem in organic chemistry that's been around for a long time," Walba says. "Chemists are intrigued with symmetry," he says, and the Möbius band "is a unique structure with novel and esthetically pleasing properties."

Chemists' increased ability to synthesize such unique and esthetically pleasing structures has contributed to the recent growth in the field of chemical topology. In some chemical circles, topology has come to mean studies of novel molecular rings; more broadly defined, it is the study of patterns among the atoms connected to other atoms in molecules. "People are interested in topology because it's so fundamental—because it's got to be controlling things [in chemistry]," says Steven H. Bertz of Bell Laboratories in Murray Hill, N.J. Bertz included topological concepts when he created the first "general index of molecular complexity" — a mathematical equation, published last year in the June 17 JACS, that eventually might be used to determine the most efficient synthetic route among the several different ways to make a particular complex chemical.

Meanwhile, Walba and cohorts already have set their sights on "other topologically interesting structures." Syntheses of more highly twisted cylinders, knots and multiply looped catenanes (linked rings) are in progress, Walba says. Such research, he says, is "so intellectually pleasing."

—*L. Garmon*



Walba et al./JACS