lipid transferase–independent activity, or it could recruit a "fission factor" to the Golgi membrane. Another unresolved issue is whether CtBP3/BARS is mitotically regulated such that its fission-promoting ability is stimulated during cell division.

Interestingly, inactivation or depletion of CtBP3/BARS prevented entry of cells into mitosis, an effect attributed to the block in Golgi fragmentation that occurs in these cells. This phenomenon has previously been seen when using reagents that block protein function in the Golgi matrix (*8*). Thus, disassembly of the Golgi appears to be important for entry into mitosis. At first glance, this seems paradoxical: If the Golgi fragments after cells have entered mitosis, as seems to be the case, then how can its fragmentation be required for mitotic entry? A possible solution comes from the finding that cells have the capacity to retreat from the earliest mitotic stage (prophase) if conditions are not right (*9*). It is possible that the cell senses Golgi fragmentation in early mitosis, and if something is amiss rapidly exits prophase, returning to the premitotic G_2 phase. Irrespective of the mechanism by which CtBP3/BARS inactivation blocks mitotic entry, the susceptibility of this protein to small-molecule inhibitors suggests that it may prove a worthwhile target for drugs to prevent the proliferation of cancer cells (*10*). The discovery of CtBP3/BARS as a key regulator of Golgi disassembly in mitosis is an exciting advance. The challenge now is to define the mechanism by which it operates.

References

1. C. Hidalgo Carcedo *et al.*, *Science* **305**, 93 (2004).
2. J. Shorter, G. Warren, *Annu. Rev. Cell Dev. Biol.* **18**, 379 (2002).
3. J. Seemann, E. Jokitalo, M. Pypaert, G. Warren, *Nature* **407**, 1022 (2000).
4. F. A. Barr, B. Short, *Curr. Opin. Cell Biol.* **15**, 405 (2003).
5. M. A. De Matteis *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **91**, 1114 (1994).
6. S. Spano *et al.*, *J. Biol. Chem.* **274**, 17705 (1999).
7. R. Weigert *et al.*, *Nature* **402**, 429 (1999).
8. C. Sutterlin, P. Hsu, A. Mallabiabarrena, V. Malhotra, *Cell* **109**, 359 (2002).
9. C. L. Rieder, R. W. Cole, *J. Cell Biol.* **142**, 1013 (1998).
10. R. Weigert *et al.*, *J. Biol. Chem.* **272**, 14200 (1997).

ASTRONOMY

Imaging the Sun's Eruptions in Three Dimensions

John C. Raymond

Observations of the Sun and the solar corona reveal complex structures in exquisite detail, and they give us the opportunity to understand the processes that heat the corona and drive the solar wind. However, interpretation of the observations is often ambiguous because we observe three-dimensional structures projected onto two-dimensional images. In particular, the stressed magnetic field configurations that lead to violent solar events are inherently three-dimensional. Among the most interesting are solar flares (the huge explosions from the Sun's surface that occur over several minutes) and coronal mass ejections, or CMEs (bubbles of gas that emerge over hours; see the figure, this page). As Moran and Davila report on page 66 of this issue, it is possible to recover a rich variety of three-dimensional structural information about these events (*1*) from two-dimensional data.

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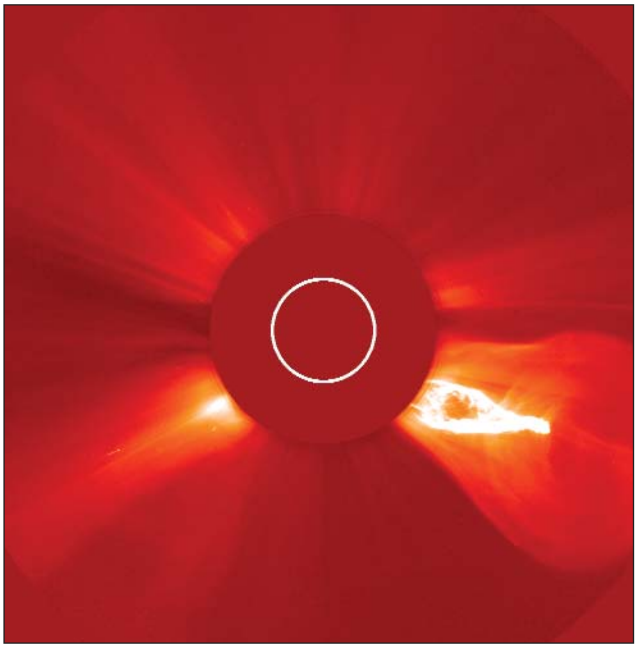
When solar activity is at a minimum, the coronal structure is stable enough that observations over a 27-day rotation period can be used for a tomographic reconstruction, much like a medical CAT (computerized axial tomography) scan. This has been done for white light scattered from electrons (*2*) and for individual ultraviolet spectral lines (*3*). Transient events such as CMEs, however, cannot be treated by tomographic methods, yet they are extremely important. Although they carry only a modest fraction of the mass in the solar wind, they can produce violent "space weather" events that can disable satellites and endanger astronauts (see the figure on the next page). For example, a CME at the end of October last year caused spectacular auroral displays, but also caused problems with power grids and communications.

The three-dimensional structure of CMEs is especially important because it is related to the direction of the magnetic field, which is a controlling factor in the strength of the space weather effects. Moreover, the helical structure observed in many CMEs is related to magnetic helicity. Although there is active debate about this, conservation of magnetic helicity may govern CME evolution in interplanetary space (*4*), and CMEs may play an important role in the dynamo process that generates solar magnetic fields by shedding magnetic helicity (*5*).

One technique for inferring the three-dimensional structure is to measure Doppler shifts of spectral lines and combine the inferred velocities along the line of sight with a series of images that show the structure in the plane of the sky (*6*). Another technique is to image the CME from different points of view. The two STEREO (Solar-Terrestrial Relations Observatory) spacecraft scheduled for launch in November 2005 will move apart from each other along the Earth's orbit to produce stereoscopic images.

A new technique for recovering infor-



Coronal mass ejections and coronal streamers. A CME observed by the LASCO instrument aboard the SOHO spacecraft. The white circle indicates the apparent size of the Sun behind the LASCO coronagraph occulter. The image shows light from the solar disk scattered by electrons in the corona. The complex structure to the lower right is a CME expanding at 750 km/s.

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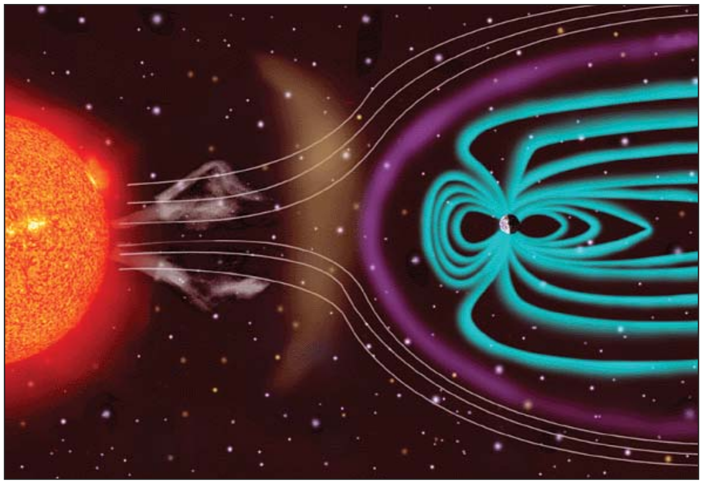

A change in the space weather. A schematic diagram of the interaction of the magnetic field of a coronal mass ejection with Earth's magnetosphere, which can produce spectacular auroral displays and knock out communications satellites.

mation about the three-dimensional structure is demonstrated by Moran and Davila (*1*). When light is scattered by electrons in the CME it becomes polarized, and its polarization fraction depends on the angle of the scattering. Thus, the measured polarization can be used to determine the scattering angle. For each point in a coronagraph image, the method yields a weighted average distance of the scattering plasma from the plane of the sky. Given that information, Moran and Davila construct images of CMEs observed by the LASCO (Large Angle and Spectrometric Coronagraph) experiment aboard the SOHO (Solar and Heliospheric Observatory) spacecraft as they would appear from above the solar north pole or from a position to the east or west of the Sun.

The new method promises to be important for estimating the angle at which a CME emerges from the Sun, and therefore the likelihood that it will strike the Earth. It will also help resolve questions about CME structure. For example, there is still debate about whether the roughly circular structures at the leading edge of a CME should be interpreted as the projections of more or less spherical shells or as bright expanding loops. The reconstruction method can be applied to many existing CME observations obtained by LASCO.

The polarization technique, STEREO imaging, and spectroscopic techniques are all mutually complementary in that they provide different ways of viewing a solar ejection structure. The polarization technique gives an average distance from the plane of the sky, whereas spectra provide the distribution along the line of sight of a selected, denser gas at specific temperatures. STEREO images provide a full three-dimensional picture, but only the simplest structures will be amenable to a direct reconstruction, and most will require interpretation based on models. Together, these methods will greatly enhance the capability for forecasting space weather and the understanding of the physical processes that drive CMEs.

References

1. T. G. Moran, J. M. Davila, *Science* **305**, 66 (2004); published online 27 May 2004 (10.1126/science.1098937).
2. R. Frazin, P. Janzen, *Astrophys. J.* **570**, 408 (2002).
3. A. Panasyuk, *J. Geophys. Res.* **104**, 9791 (1999).
4. A. Kumar, D. M. Rust, *J. Geophys. Res.* **101**, 15667 (1996).
5. B.-C. Low, *J. Geophys. Res.*, **106**, 25141 (2001).
6. A. Ciaravella *et al.*, *Astrophys. J.* **529**, 575 (2000).

NEUROSCIENCE

Let There Be (NADH) Light

Luc Pellerin and Pierre J. Magistretti

Oxidation of glucose is thought to provide almost all of the energy needed by neurons to support brain activity. Indeed, glucose consumption is tightly linked to neuronal activity in the brain. For decades, these two principles have driven the study of brain energy metabolism and its relation to brain activity. They also provide the foundation for a brain imaging method called 2-deoxyglucose autoradiography that maps regional brain activation as animals undertake different tasks. This method, developed by Sokoloff (*1*), has been used in combination with another imaging technique, positron emission tomography (PET), to study brain activation under different conditions in human subjects. However, the traditional view that glucose is consumed directly and solely by neurons and that glucose consumption directly reflects neuronal activity is under challenge. In vitro, ex vivo, and in vivo experiments have shown that astrocytes, a type of glial cell in the central nervous system, respond to neuronal activity mediated by the neurotransmitter glutamate by consuming more glucose as well as producing more lactate (*2*). In parallel, neurons preferentially oxidize lactate present in the extracellular space rather than glucose to meet their energy demands (see the figure). The overall process has been designated the astrocyte–neuron lactate shuttle hypothesis (*3*). Despite growing interest in this hypothesis, there has not been a clear demonstration that activation of glycolysis (anaerobic glucose metabolism) in the cytoplasm and of oxidative phosphorylation (production of ATP) in the mitochondria are effectively segregated between astrocytes and neurons. On page 99 of this issue (*4*), Kasischke and co-workers now provide illuminating evidence to support this view.

These authors studied changes in NADH (the reduced form of nicotinamide adenine dinucleotide) in rat hippocampal slices using two-photon fluorescence imaging and confocal microscopy. Alterations in NADH concentration—the major contributor to the fluorescent signal—provide a signature of glycolysis or oxidative phosphorylation activity in the cytoplasm or mitochondria of astrocytes and neurons in the hippocampal brain slices (see the figure). With confocal microscopy, the authors were able to identify the fluorescent signal as emanating from either the cytoplasm or mitochondria of astrocytes or neurons.

The authors stimulated the Schaffer collaterals of CA3 neurons in the hippocampal slices and monitored the intrinsic fluorescence signal in the CA1 hippocampal area. At low magnifications of the confocal microscope, the tissue presented a biphasic response: An initial "dip" in the NADH level followed by an "overshoot" that reproduced previous in vivo measurements. At higher magnifications, however, the authors were able to resolve both spatially and temporally the response in the two components. The early "dip" in the fluorescent signal and its recovery to baseline was restricted to the dendrites of neurons in a small area of the hippocampus. From the mitochondrial origin of the fluorescent signal, the authors deduced that the response represented first an increase in oxidative phosphorylation (respiration) in which NADH is consumed, followed by activation of the tricarboxylic acid (TCA) cycle to replenish NADH. In contrast, the late "overshoot" fluorescent signal

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