Spin Control

How the UW and high-tech mapping may figure into the Tour de France.

When the Tour de France begins in July, many people will be watching to see if Lance Armstrong can win the cycling race for an unprecedented seventh consecutive time. But for **Jeff Sledge,** the real interest is in how one of Armstrong's top rivals fares.

Sledge, a researcher with UW-Madison's Land Information and Computer Graphics facility, helped design equipment that American rider Floyd Landis will use to monitor his energy consumption during the race. As the mountains of France test Landis's body over the course of the grueling three-week event, they'll also test the promising new technology, yielding information that could benefit many more people than just elite cyclists.

"From a research standpoint, this is one of the very few opportunities we get to measure people who are putting out energy at the limits of human performance," says Sledge, who developed the equipment in cooperation with Saris Cycling Group, a Madison company that manufactures high-end cycling gear. "We expect to learn a lot."

WOLFGANG HOFFMAN

A device installed on the wheel of Jeff Sledge's bicycle logs data about the bike and its rider, including the torque and energy produced by the bike. After putting in hundreds of miles testing this "rolling laboratory," Sledge will soon learn how the equipment does in cycling's premier event, the Tour de France.

The system involves a unique marriage of physiology and the tools of high-tech mapping, an outgrowth of Sledge's graduate studies in land resources. While many performance monitors measure a rider's heart rate or pedal cadence, the new device is one of the first to combine those data with his or her exact location, which is tracked using a bike-mounted global positioning system (GPS). The result is that it can learn to predict how much energy a rider will need to complete a particular route, given its geography.

For racers like Landis, that means instant feedback on how their bodies are performing at every point on a race route, enabling them to gauge whether they need to conserve energy or crank it up. When

Beam Me up North

They're coming from Illinois, plowing through Wisconsin en route to northern Minnesota. But these tourists won't clog up the roads. In fact, you won't even know they're there.

That's because they are neutrinos, subatomic particles that zip through the universe unhindered by planets and matter. Scientists have begun beaming the tiny particles through subterranean Wisconsin as part of a five-year project aimed at demystifying their elusive nature.

Produced by nuclear reactions on the sun and other stars, neutrinos have almost no mass and no charge, says **Albert Erwin,** a professor of physics who is participating in the project. Yet he and other researchers believe neutrinos play a role in the formation of atom-building particles such as protons, neutrons, and electrons.

SPENCER WALTS

To understand them better, they are aiming a beam of neutrinos from the Fermi National Accelerator Laboratory in Batavia, Illinois, toward a detector set deep in an old iron mine in Soudan, Minnesota. They hope to take more accurate measurements of the particles, but the window of opportunity is small. The particles make the 450-mile trip in about two and a half milliseconds. Typical Illinois drivers.

— Staff

Landis used the technology during a time trial at the Tour of Georgia earlier this year, he not only won, but he beat Armstrong by more than a minute. If the France test goes well, Saris — which supplied Sledge with equipment and expertise — plans to market the system as part of its CycleOps brand of training products.

But researchers who have collaborated on the project are equally excited about how the technology may soon be used by those outside the exclusive circle of endurance athletes. Understanding how much energy it takes for people to move across a particular landscape could turn up all kinds of new insights, which may influence anything from how doctors treat childhood obesity to how city planners design bicycle and pedestrian routes.

"We think it's one of the coolest things that's come down the road in a while," says **Randy Clark '80, MS'84,** manager of the UW's Exercise Science Laboratory. "It's still very new, but it's groundbreaking stuff. There's great potential there."

The promise lies in the integration of time- and space-related data. As the bike rolls along, its GPS unit communicates with satellites, both tracking position and tapping into huge databases of information about the landscape, including elevation, terrain, and atmospheric conditions. Those specifics put the physiological data collected by other monitors into a geographical context, accounting for hills or high winds that might affect someone's performance. The information is logged in a file that can be broken down second by second, like an instant replay of your ride.

Clark's lab has begun using the monitors as part of an ongoing study of childhood obesity, for which a local school has been assigning students bike rides as "homework." Having a GPS record of where the kids go not only makes it virtually impossible to cheat, it also reveals how different routes affect their bodies, which could help doctors tailor exercise regimens right down to the exact route they should take. The same kind of test might help bike commuters find routes that allow them to pedal to work without getting tired and sweaty.

For Sledge, a triathlete who bicycles three hundred miles a week, that hits close to home. He never set out to design technology that would be used at cycling's premier event when he began experimenting with GPS data as a doctoral candidate in the Gaylord Nelson Institute for Environmental Studies. He chose to focus on the sport mainly because it supplied the dynamic data he needed to make real-time assessments. Still, he's an avid fan, and this year he'll closely monitor Landis's progress from his computer in Madison.

"Obviously, I want to see Floyd do well and the CycleOps equipment do well," he says. "But the goal all along has been to create something that helps people at all levels." And that's why, after this year's race, the guy in the yellow jersey may not be the only one who comes out a winner.

— Michael Penn

COOL TOOL

Lake Effect

JEFF MILLER

How's the water? A research buoy floating on Wisconsin's Trout Lake keeps a vigil.

In southern Wisconsin, lakes are paying the price for our perfectly manicured lawns and productive farms. Phosphorus from fertilizer runs off into the water, creating a problem known scientifically as eutrophication, and to everyone else as a lot of algae. Researchers from the UW Center for Limnology are studying the phenomenon with a powerful buoy.

Tim Kratz, a senior scientist with the center, directs the UW's research station at Trout Lake in northern Wisconsin, where the instrument floats on the water. The buoy measures differences in water temperature, dissolved oxygen, wind speed, and other factors to create a picture of what's going on under the surface. "We want to learn how metabolic processes are changing in the northern lakes over time," says Kratz.

Researchers are hoping to learn how the makeup of the lake is changing by studying dissolved gas concentrations in the water. At night, tiny lake organisms consume oxygen, and during the day, they consume carbon dioxide. When too many nutrients are added to the lake, the rate of metabolism speeds up, resulting in algae blooms. And though it's not a major problem in Trout Lake, the research could help create a greater understanding of how lakes react to change.

— Erin Hueffner '00

Fascination in Summation

A grad student unravels a legendary numerical mystery.

Early in the last century, Srinivasa Ramanujan scribbled a few notes into a tattered notebook and sparked one of the great lingering mysteries of mathematics. Now, a UW-Madison graduate student has solved a problem that has haunted generations of number theorists.

After a year of calculations, **Karl Mahlburg PhDx'06** found a formula that helps explain Ramanujan's congruences — the curious patterns in the ways that numbers can be broken down into sums of smaller numbers, which the legendary mathematician noted in his journals.

"This [work] is the final chapter in one of the most famous subjects in the story of Ramanujan," says math professor **Ken Ono,** Mahlburg's graduate adviser and an expert on Ramanujan's work.

The father of modern number theory, Ramanujan was born in India in 1887. Growing up in poverty, he received little formal training in mathematics, yet produced a vast body of work before contracting a mysterious illness that took his life at age thirty-two. He is particularly famous for observing how numbers break apart into "partitions," or sums of smaller numbers.

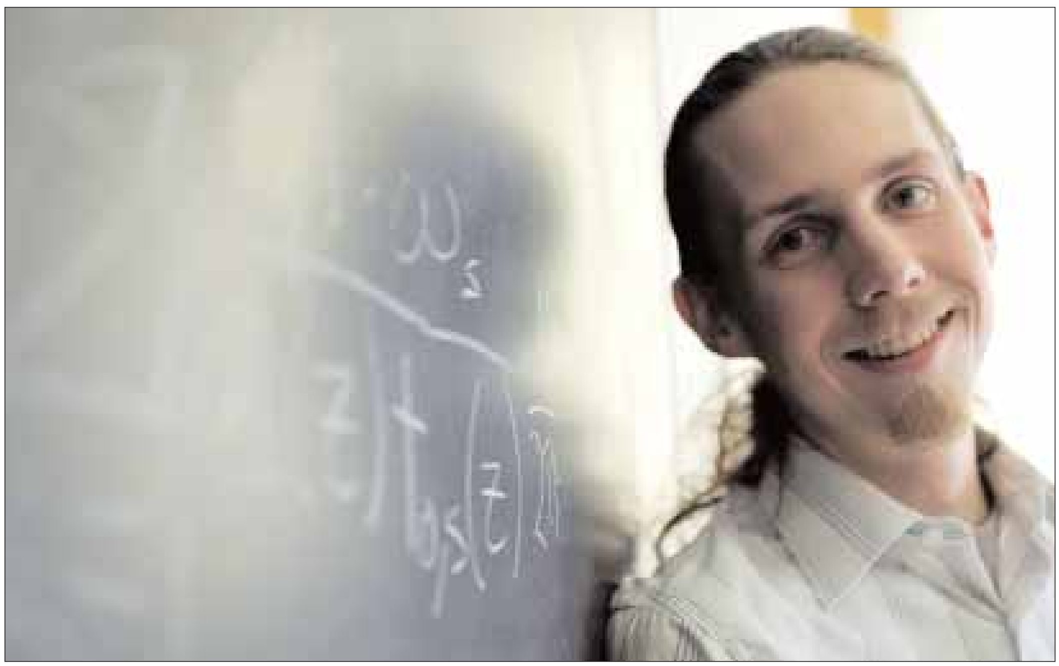
The number 4, for example, can be expressed five ways — 4, 3+1, 2+2, 1+1+2, and 1+1+1+1 — giving it five partitions. Working with the prime numbers 5, 7, and 11, Ramanujan noticed patterns that seemed more than just mere coincidence: beginning at the number 5, for instance, the number of partitions for every seventh integer is a multiple of 7, and starting with 6, the partitions for every eleventh integer are a multiple of 11.

For decades, mathematicians inched forward in the search for elementary ways to explain Ramanujan's elegant discoveries. In the 1990s, however, came a breakthrough that nobody could have anticipated. Working on an unrelated problem, Ono spotted an obscure formula embedded in Ramanujan's scrawl, and the chance sighting led him to the amazing discovery that congruences exist not only for 5, 7, and 11, but for all larger prime numbers.

The finding entranced Mahlburg, who began searching for simple ways to explain the patterns in all of these congruences. After manipulating "ugly, horribly complicated" numerical formulae for a year, he says he began to see a pattern.

Mahlburg's solution is sufficiently complex to fill every page of this magazine, so it's enough to say that in the eyes of number theorists, he came up with "a fantastically clever argument," says Ono. And in the story of a math legend's great quandary, that's a great addition.

— Paroma Basu



WISCONSIN STATE JOURNAL/WWW.MERLIN-NET.COM

After a year of calculations, Karl Mahlburg came up with a solution to a legendary mathematics mystery.

WISCONSIN IDEAS

Scientists have discovered a pathway by which **plant cells** protect themselves from the harmful effects of the sun, a development that could hold important implications for agriculture and the development of bioenergy resources. The research explains how plants are able to ward off a potentially toxic byproduct of photosynthesis known as singlet oxygen. With that knowledge, it may be possible to modify plants and other photosynthetic cells to harness more energy from sunlight without increasing the risk of damage from singlet oxygen, which could improve crop yields or the efficiency of solar energy resources.

A **homing device** that helps firefighters find their way out of burning buildings won top honors at the College of Engineering's annual Innovation Days. Designed by students Nick O'Brien, Chandler Nault, and Mitch Nick in cooperation with Madison firefighters, the system uses radio transmitters to beam directions to firefighters when they're navigating smoke-filled buildings. The competition's $10,000 prize will go toward developing and marketing the system.

A team of UW-Madison scientists successfully used single bacterial cells to make tiny bio-electronic circuits, which could facilitate the evolution of **nanotechnology** by making it far easier to manufacture the tiny devices. Using microbes as the basis for nanoscale structures could spare nanotechnologists the meticulous work of fabricating devices at the tiny scale, opening the door to a new wave of tools that are faster and easier to build.