



# The Spectrogram

## A Telescope with a Primary Mirror made of Liquid Mercury???

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So many astronomers, so little time -- telescope time that is. Today's behemoths cost hundreds of millions of dollars. Since individual ownership is impossible they must be shared. Until now. Later this year, at a cost of slightly more than a million dollars, a team of astronomers has exclusive use of a telescope larger than the Mount Palomar giant. What makes it inexpensive is not the ski chalet-like wood frame observatory or the aluminum tubes that suspends the instruments over the main mirror, but the mirror itself. By a happy accident of physics, a spinning liquid forces its surface into the perfect shape for a telescope mirror. Capitalizing on this, scientists at the University of British Columbia (UBC) have built a 236-inch (6-meter) Liquid Mirror Telescope, or LMT, set to capture its "first light" later this summer.

A telescope mirror's job is to hold a thin reflecting layer in the right shape. Over the years astronomers have used polished metal, solid glass and large mirrors created from many smaller ones.

The LMT uses a dish of liquid mercury. If it works, "classical telescopes with solid mirrors will go the way of the great refractors that were replaced with reflecting telescopes," said physicist Ermanno Borra.

Turn, turn, turn

Imagine a lazy Susan holding a bowl full of water. When spinning, the water's surface becomes the perfect shape for a telescope mirror. If the liquid is mercury, an excellent telescope mirror is formed, the core of a Liquid Mirror Telescope [LMT].

Cosmologist Paul Hickson is using this physics to make the world's 13th largest telescope. It collects starlight with a plate of mercury 6 meters across spinning at about 5 rotations per minute.

This University of British Columbia telescope costs about \$1 million. A conventional telescope with a regular solid glass mirror of the same size would require an outlay of about \$100 million. A large part of the savings comes from not making, polishing, testing and mounting a standard mirror.

The low cost means Hickson and his fellow cosmologists are able to afford a large telescope for their exclusive use to do the science they would like to do -- but can't.

"I didn't start out to be a telescope builder. I only wanted to build a telescope, collect good data and get scientific results," Hickson said.

What's old is new again

It sounds simple: Spin a plate of mercury, place a camera above it at the focal plane and -- voila -- a telescope is born. Yet making it work wasn't easy. The concept of LMTs can be mapped back to the 18th century. Experiments that utilized the concept were conducted in the 1800s and the early 1900s, but the results were disappointing.

### Fact of the Month

The space shuttle, including its booster rockets, weighs about 4,400,000 pounds at liftoff. The space shuttle orbiter, the reusable craft, weighs between 200,000 and 240,000 pounds, depending on the weight of its payload.

## Important Announcements



- **The next S\*T\*A\*R meeting** will be held on **Friday**, November 3, 2000 at 8 PM at the Colts Neck Fire House #2 on Conover Rd. in Colts Neck. Please note the day change for this month, to accomodate our speaker, who is travelling a rather large distance to be with us. Author and educator Phil Harrington will be our speaker. He will bring us from the humble beginings of astronomy to the latest technology of today in his talk entitled ``Nights of Future Passed''. Phil is an excellent writer and speaker. If you make it to only one meeting this year, this is the one! **Directions:** From Rt. 520, turn south onto Rt. 34. Conover Rd. is on the right, one light south of Rt. 520. From Rt. 537, turn north onto Rt. 34. Conover Rd. is on the left, two lights north of Rt. 537. The fire house is on the right, just a couple of blocks off of Rt. 34.
- **The Spectrogram wants you!** Big thanks to Paul Nadolny for the excellent monthly column! I'm happy to say that Ed Collett will be adding one as well. Looks like we will need to add more pages to the newsletter! If you would like to contribute an article, or news item, or if you have questions or suggestions, please contact me via email at [fblock@monmouth.com](mailto:fblock@monmouth.com). Also, if you have been receiving the newsletter in the mail and have an email address, help us reduce paper newsletters by reading The Spectrogram online! Please let John Gasparini know your email address.
- **STAR Sweatshirts:** Mike Lindner is collecting info from everyone that may be interested in a STAR Sweatshirt. Hooded or non hooded? White or Grey? Mike wants to know! Please see him at the next meeting if possible.

## Upcoming Events and Star Parties



*There really aren't many more star parties or events scheduled for this year from what I have found. If you know of one that should be listed in the newsletter for next month, please let me know.*

- **November 4, New Jersey:** The **Jersey Astro-Conference and Showcase** is hosted by Amateur Astronomers Inc. and Union County College, on the UCC college campus located at 1033 Springfield Ave, Cranford NJ 07016. Events include several guest lectures, displays and vendors. Contact AAI at [jacs@astersim.org](mailto:jacs@astersim.org) or PO Box 111, Garwood NJ 07027-0111 or at 908 276-2730. For more info. <http://www.asterism.org>.
- **December 31, Washington D.C.** On New Years' Eve, the U.S. Naval Observatory will celebrate the beginning of the Third Millennium under the stars with a free **Open House** featuring music, displays, telescopic viewing of celestial objects (weather permitting), and a concluding celebration at the stroke of midnight. At that precise moment, a time ball will be released from a mast on the roof of the Observatory's Main Building, signaling the official arrival of the new millennium in the United States. Entrance to the Observatory will be on a first-come, first-served basis for the first 3000 people, beginning at 10 pm. Enter the grounds on foot at the Gilliss Avenue gate at the corner of Observatory Circle and Massachusetts Avenue, NW, near the British Embassy. Coolers and packages will not be permitted on the grounds, and all persons must be prepared to submit to a security check. Limited parking is available outside the grounds on Observatory Circle. More information on Observatory millennium events, the date of the new millennium, and the Observatory's work in general may be obtained at <http://www.usno.navy.mil/>.

## A Telescope with a Primary Mirror made of Liquid Mercury??? (Continued from Front Page)



The concept was sound, but the technology available was too crude to make it work. Vibrations from the ground around the telescope made image-smearing waves in the mercury. To achieve sharp images, the focal plane must not move. This requires the rotation of the vessel holding the mercury to vary less than one part in 100,000 during the exposure. Following these experiments, LMTs were a curiosity in the history of physics until the early 1980s. "It was nearly a forgotten concept that had a bad reputation because past attempts were unsuccessful," said Borra. After rethinking the idea, he thought that this mirror married to modern technology would give birth to a large, cheap telescope. In Borra's Laval University lab he began to first experiment with a 19.7-inch (50-centimeter) mirror, quickly progressing to one at 39.5 inches (1-meter). After about a decade, he fabricated a mirror that produced images equal to those made by conventional glass mirrors. He and his students figured out how to use air bearings to support the vessel holding the mirror. To get sharp images, they also cast a layer of epoxy resin atop the mercury and used a crystal-controlled motor to keep the rotational speed constant. A telescope needs more than a mirror. "[I] had been following Borra's work and I realized this could be a way to build a large, low-cost telescope for cosmological surveys" said Hickson.

To discover the large-scale structure of the universe Hickson needs to map the position and distance of millions of galaxies. Only a large telescope will allow him to see the faint galaxies to make this effort worthwhile. Hickson's hobby is building and flying aircraft, which provided him the base of knowledge to use and shape composite materials like Kevlar and carbon fiber. He invented a lightweight, yet strong cell to hold the mercury. In the event of a mercury-spilling cell breakage, Hickson dug a waist-deep, epoxy-lined concrete pit to contain the spill. To this floor was bolted one end of an aluminum tube hexapod. At the other end, directly above the mirror, is attached a platform holding the CCD cameras and other instruments. This represents another cost-saving measure, since the massive piece of metal, called a telescope mount, is eliminated. Hickson noted: "We just throw the mount away." A costly dome, which shelters many large observing telescopes, isn't required since LMTs only point straight up. At the UBC research forest, 60 miles (97 kilometers) east of Vancouver, British Columbia, Hickson built a ski-chalet-type, 4-story wooden building which uses a roll-off roof.

With the exception of the air bearing and other specialty items, the LMT was built by Hickson and his graduate students, or by tradesmen using locally purchased materials. The result was a professional-sized observatory with a cheap price tag.

Hickson's first LMT, built in 1993, was 106-inches (2.7-meters). It was intended to be a "proof-of-concept" instrument, but from the beginning the results were "about the same as a conventional glass-mirrored telescope" he said. This proved LMTs' astronomical worth. It was dismantled two years ago to make way for its larger sibling. "We're taking it one step at a time. We know how to build 3-meter (118-inch) telescopes and we're now developing the technology to make larger ones," he said. The 6-meter starts operation later this year. Hickson built a near twin of his first LMT for NASA in 1996. It scans low Earth orbit for space junk too small for ground-based radars to see. So far it is finding five times as much stuff as the radars see.

Own your own Palomar. Just as many of us feel like we're not paid enough, many astronomers believe they never get enough time on a large telescope. With new observatories costing \$100 million or more, there is no way an individual or a team of like-minded astronomers could hope to own one for their own use. This leads to rationing. Even astronomers with the most exciting ideas must be satisfied to work with a state-of-the-art instrument like the Keck Observatory in Hawaii for no more than three or four nights a year. This shortage is holding back cosmological research. Borra notes that in order to do meaningful work on the large-scale structure of the universe, one must pin down the location and distance of millions of galaxies. Hickson explained he could tie up Palomar's 200-inch (5-meter) telescope for five years to do this survey. With astronomers lined up to use it, that is not going to happen. But with LMTs, the day of individual astronomers owning their own telescopes may have dawned.

"This is the beginning of an exploration into unexplored technology," said Hickson.

## Controlling Light Pollution in Eatontown Revisited



Apparently, I had left out a part of this article by John Batinsey in last month's newsletter. Here is what was missing.

The Association of New Jersey Environmental Commissions quarterly publication reaches 556 municipalities throughout the State. A copy of the article was sent to each astronomy club in New Jersey. I urged each club form a light pollution committee to coordinate and coax other club members to call and write to their municipal officials. I will work with each committee to provide any guidance that may be necessary. We've done it in Eatontown and the process works if approached properly. After a committee is formed, I would like to take its members on the Eatontown lighting tour. You can reach me on (732)542-0607. ANJEC has informed me that some local environmental commissions have already asked for a copy of the "Outdoor Lighting Guide" (referred to in the article). To reinforce those commissions that have done this, and to jump-start those who have not, each club member should contact their local environmental commission. Suggest that your municipality should also consider adopting a light pollution ordinance. You can further suggest that they contact me as they will likely have some questions. I would also recommend that your club members also write (form letter) to their local mayor expressing the same concerns. There's nothing like hearing from local voting residents to get things going.

## What's in the Sky This Month (*From Skypub.com*)



**Editor's Note:** *I had been getting this part of the newsletter from Astronomy.com. They had a great part of the site that told you what was up and coming for us to look for. Well, they "fluffed" up the site and it is HORRIBLE in this Editor's opinion. Turns out that Sky and Telescope's site will be able to fit the bill. Sorry for the rant. Anyone else look at the "new" Astronomy.com?*

- When the waning gibbous Moon rises on Sunday evening, **November 12th**, an **occultation of the Hyades** will already be in progress. With binoculars or small telescopes, observers across most of the U.S. can see the bright stars Delta, 64, and 68 Tauri (also known as d1, d2, and d3) pop out from behind the Moon's dark limb at the following times: 8:25, 8:43, 9:41.
- **Leonid Meteor Alert for Eastern North America:** There could well be another grand Leonid meteor storm this year - and this time, eastern North America could be the place to be. So say Carola Göckel and Rüdiger Jehn (European Space Agency) in the September 1st Monthly Notices of the Royal Astronomical Society. These specialists fully confirm the times calculated earlier by Robert McNaught and David Asher for the Earth's encounters with particles from the Leonids' parent comet, 55P/Tempel-Tuttle (see *Sky & Telescope* magazine, June 2000, page 34). But they differ greatly in the meteor rates expected. Göckel and Jehn conclude that a very rich display of Leonids may appear near 7:53 Universal Time on November 17th (2:53 a.m. Eastern Standard Time, 1:53 a.m. Central). Another investigator, Ignacio Ferrín, has already predicted a meteor storm for an hour and a half later, around 9:24 UT on the 17th. Asher and McNaught, however, believe that this portion of the shower (caused mainly by particles released from the comet in 1932) will be weak. They favor the morning of the 18th, near 3:44 UT (best for western Europe) and again 7:51 UT (best for eastern North America). They also predict that these peaks on the 18th will be unimpressive, with only a few dozen meteors visible per hour. In any case, observers in the Eastern, Central, and possibly Mountain and Pacific time zones of North America should be out watching on the **morning of Friday, November 17th!** Keep a vigil from about 1 a.m. local time until the first light of dawn. If Göckel and Jehn are right, the November 17th shower will be about half as strong as last year's great Leonid storm over Europe and Africa, when rates briefly reached one meteor per second. Unfortunately, the last-quarter Moon will be quite bright.



## Astronomical Fact and Fiction – *by Paul J. Nadolny*

For the last few years, the Leonid meteor shower has made each November special in anticipation of a possible meteor storm. Unfortunately, the mass media's explanation often makes it sound like a comet whooshes by the earth, raining us with fiery debris. People are often confused about the distinction between comets and meteors.

One common misconception is that a comet visibly flies through the night sky, with its tail blazing behind it. There are two mistakes here: speed and direction. From earth, a comet appears to move about as slowly as the planets. That's because comets are in orbit around the sun, so they are far from earth, usually hundreds of millions kilometers away. If one were to observe a comet from night to night, it would seem to be in a slightly different place each night, but it would not appear to fly through the sky any more than a planet would. The fact that a comet has a tail reinforces the mistaken notion that one should be able to see the comet visibly moving. The comet's tail brings us to the second mistake: direction. It seems to make perfect sense that if an object is moving, and it has a tail, the tail must be trailing behind. After all, when animals run, their tail trails behind. When jet planes fly high enough in the right atmospheric conditions, the white contrail trails behind. But alas, with comets, this is not the case. The visible tail of a comet is created when the comet moves close enough to the sun for its ices to sublimate to gases. The fast-moving solar wind then pushes the gases away, forming a tail. The weird result of this is that the tail always points away from the sun, whether the comet is approaching or receding. While a comet approaches the sun, the tail is generally behind the comet. But after a comet rounds the sun and begins to recede, the tail actually moves ahead of the comet. Finally, as the comet gets far enough away from the sun, the ices are no longer warm enough to form a tail, and the comet spends most of the rest of its orbit tailless.

Although a comet's tail does not actually trail behind it, there is something that does. As the ices turn to gases, small particles the size of dust and sand are released as well. They have too much mass to be blown away by the solar wind, so they orbit the sun in the same path as the comet. Over the course of many sunward passages, more and more particles are released, and they eventually litter the comet's entire orbit. How do we know about such small particles? If the earth happens to intersect the comet's orbit, these particles shower us over the course of a few hours or days as the earth moves through them. This is what we call a meteor shower. When the particles hit the earth's atmosphere on the night side of the planet, they burn up and we see them as "shooting stars". So comets do not visibly fly through the night sky after all – that honor belongs to meteors.

Incidentally, there is a certain naming scheme that goes along with meteor showers. Often people use the terms "meteor", "meteoroid", and "meteorite" interchangeably, but they have different meanings. When the cometary dust particles are in orbit, before the earth runs into them, they are called "meteoroids". One way to remember this is that the "-oids" are in "orbit", as asteroids, planetoids, and meteoroids. When a meteoroid enters the atmosphere and burns up, it is called a "meteor". Remember that "*meteorology*" is the study of the weather and the atmosphere, which is where meteors burn up. Finally, if a meteoroid is large enough, it can survive the trip through the atmosphere as a meteor and hit the ground, becoming a "meteorite". Remember that most names of rocks on earth end in the suffix "-ite" or "-ate", so a meteorite is a rock on the ground that used to be space debris.

So what about the possibility of a Leonid meteor **storm** this month? Why is that more newsworthy than a plain old meteor shower? When the earth moves through the meteoroids in a comet's orbit, the comet is not usually close by – comets spend most of their time in the outer reaches of the solar system. The density of meteoroids along most of a comet's orbit is relatively low, producing 10 to 100 meteors an hour in a very dark sky. But sometimes the earth passes through the meteoroids shortly after the comet has passed through that part of its orbit. The concentration of meteoroids is much higher in the wake of the comet compared to anywhere else in its orbit. When the earth travels through a particularly dense area, the number of meteors per hour can be in the thousands or higher! This is the much anticipated meteor storm, the only atmospheric "storm" that astronomers eagerly await.

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Here it is! This month's issue of...

# THE SPECTROGRAM

## This Month's Puzzle

Match the scientist's name with a word that is associated with them. For each scientist or word there may be multiple associations, so it is up to you to use logic to choose associations such that each name has exactly one match. The answers are below in fine print. Make sure you don't cheat!

- |                   |               |
|-------------------|---------------|
| 1. D'Arrest       | a. black hole |
| 2. Encke          | b. catalog    |
| 3. Flamsteed      | c. comet      |
| 4. Galle          | d. gaps       |
| 5. Hipparchus     | e. gravity    |
| 6. Kepler         | f. motion     |
| 7. Kirkwood       | g. nebulae    |
| 8. Messier        | h. Neptune    |
| 9. Newton         | i. probe      |
| 10. Rayet         | j. star       |
| 11. Schwarzschild | k. supernova  |
| 12. Tycho Brahe   | l. wolf       |

1--G 2--C 3--J 4--H 5--I 6--F 7--D 8--B 9--E 10--L 11--A 12--K