Volume 1, Issue 5 September 2006

$14.95

Triton Fun Company Science Newsletter September 2006

Science Newsletter September 2006

The Yarkovsky Effect: Pushing Asteroids Around

M. Busch

Special points of interest:

- Asteroids
- Water - delight
- Special Offers !
- Triton Fun stuff
- Superfluous questions

SPECIAL COLLECTIBLES OFFER - THIS MONTH ONLY !

SEE PAGE 3 ! Inside —>

We are always looking for contributors to the Science Newsletter. If you would like to write an article about a science subject you are excited about, or contribute a superfluous question, or if you would like to be on our mailing list for future newsletters, please e-mail us at:

science@tritonfun.com

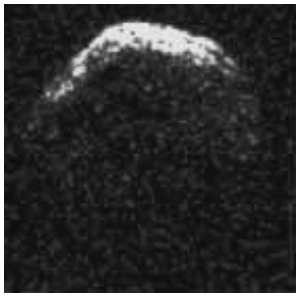
On March 16, 2880, an asteroid a kilometer across will make a close approach to the Earth. The outcome of the encounter depends critically on the physical properties of the object: surface composition and texture, the rotation state of the object, and its shape (Giorgini et al.). To understand why these should matter at all requires knowing something of the object, 1950 DA, and of a strange process called the Yarkovsky effect.

1950 DA was discovered in February 1950 by Carl Wirtanen and lost after 17 days of observation. It was not re-discovered until December 31, 2000, just before an eight-million kilometer close approach in March 2001. During this close approach, the Arecibo and Goldstone observatories obtained radar images and radar astrometry, giving the position and velocity of the object to very high precision. Because of those observations and the 1950 measurements, we can plot 1950 DA's trajectory out to 2880 and predict the Earth encounter.

But between 2001 and 2880, a large number of forces act on 1950 DA. We can try to predict the magnitude of these forces, but we are limited by the available data. The slightest deviation matters: let us say that 1950 DA is on a trajectory that would impact the Earth in 2880. The Earth is a target ~12000 km wide. If the velocity of DA changes by 0.5 *millimeters* per second, it will miss the Earth. Thus the best estimate for the impact probability is "between 0 and 0.33%" (Giorgini et al.).

Of all of the uncertainties clouding our prediction of DA's position in 2880, the largest, by roughly a factor of ten, is the Yarkovsky effect. The Yarkovsky effect is a strange process, with an equally strange history. Ivan Osipovich Yarkovsky, a civil engineer, wrote a pamphlet discussing the process around 1900. This was almost completely forgotten, but Ernst Öpik read it when he was a student and re-derived the results fifty years later (Brož).

The Yarkovsky effect is quite simple in concept: one side of the object is hotter than the other (being heated by sunlight), so it radiates more photons to space. Those photons carry momentum, producing acceleration. The process is strange because the magnitude of the force depends on the shape of the object and the temperature distribution, which follows from the thermal properties of the surface. The direction of the force is



Dangerous Rock
Radar image of Asteroid 1950 DA, obtained at Arecibo Observatory, Puerto Rico, in 2001. Range from Earth increases from top to bottom and Doppler frequency increases

determined by the rotation state, which determines the position of the hot portions of the surface. So we must know the shape, rotation state, and surface thermal properties of 1950 DA if we are to know the Yarkovsky acceleration.

I have used all available Arecibo and Goldstone radar data to estimate the shape, spin state, and surface structure of the 1950 DA. Two different models provide equally good statistical fits to the data. One rotates prograde and is roughly spheroidal with geometric mean diameter 1.16 ± 0.12 km. The other rotates retrograde and is oblate with mean diameter 1.30 ± 0.13 km. These two models have Yarkovsky accelerations roughly opposite to each other. One allows an impact in 2880, while the other

(continued, page 2 ->)

Water : An amazing substance

J. Brown

Water usage varies widely around the world. In Iraq the people have to get by on as little as 3 gallons per day. In England 40 gallons is considered necessary. The United States uses and wastes more water than any other country; 100 gallons per day would be a fair average. The first steamboat was not built by Robert Fulton as I was taught in school, but long before by James Rumsey, an innovator far ahead of his time. It had features used on modern boats, including a water-tube boiler and jet propulsion. Deceptively simple chemically, water is one of the most interesting and useful substances in all of nature. Even if we weren't largely made of it, we'd still be hard put to do without it. Having many distinctive properties, some of them unique, it has made possible the life that we know. Being fascinated by steam engines for as long as I can remember, I soon learned that their power came from the same force that lifted the lid of a cooking pot on the kitchen range. But I didn't realize until much later what enables water to be so useful for this and many other jobs. It has the highest heat of vaporization of any common substance: changing from liquid to gas (steam), it absorbs a great amount of heat energy from the fire, releasing it in the engine where it is converted into mechanical energy. This same ability (at a slower rate) enables us to be cooled by sweating. A related property, its high specific heat, again greater than any other common compound and twice that of most, means that it can absorb a lot of heat with little increase in its own temperature. It thus serves to moderate global temperatures by moving heat away from the tropics by means of ocean currents and weather. Its heat of fusion is so high that ten times as much heat energy is needed to melt a pound of ice as a pound of iron. That's why ice was so useful for refrigeration before other methods were developed. If iron were liquid at standard temperatures, an iron shower, besides not cooling us very well, would beat us to a pulp, being seven times water's density. This immense capacity for heat storage and retrieval not only makes life more comfortable, it is very likely the reason it is even possible on Earth. .

Water is the only natural substance existing in all three physical states at normal Earth temperatures. It is, with one exception, the only substance that expands upon solidification. Though troublesome at sea in the form of icebergs, this property is extremely useful to lifeforms, for if water behaved like other things and contracted when freezing, ice would sink, and water in cooler parts of the world would freeze solid. Ocean currents would cease, and temperature extremes would increase drastically. Ice, being about 11% lighter than water, floats, and, being a fair insulator, tends to stabilize the temperature of the water beneath it. Without this unique property life would be very limited, if indeed it could exist at all. ON THIS SLENDER THREAD DOES OUR EXISTENCE HANG.

Water is an unexcelled solvent; pure water exists only in laboratories, and there only with difficulty. The oceans have thus become vast storehouses of materials leached from the landmass by rainwater. Its weight seems ideal—heavier might make weather much different; lighter might cause it to escape to space.

Quite impressive for such a seemingly ordinary substance. Next time you have a refreshing drink, or a bath, or enjoy the serene beauty of a rainbow, take a moment to appreciate that wonder of the cosmos that we call water. So amazing are its properties, and so well does it serve the needs of life that there is a strong tendency to consider it the product of some conscious design, made expressly for our benefit. But the more I learned about astronomy, cosmology and physics, the less likely this idea seemed, and the more it appeared to be an extremely egotistical view closely akin to the ancient notion of a geocentric universe. A more probably view, more in line with the evidence, is that water (and the other requisites) were here, and life arose, probably inevitably because of the favorable conditions. But whatever your opinion, learn more about water, how precious it is, and why (and how) we must take care of it. It is an endangered resource and man has taken clean, fresh water for granted far too long. You, your children, and the Earth will benefit.

Asteroid, continued

has no probability of impact (Busch et al.). This result is not particularly satisfying, because of the ambiguity. However, if we obtain additional data later this year, we may be able to break the degeneracy between the two models. Then we will be able to say how far Yarkovsky will push 1950 DA between now and 2880 and determine the outcome of the encounter.

Asteroid— References:

Brož, Miroslav, Jarkovského jev a dynamika sluneční soustavy, doktorské disertační, Univerzita Karlova. (Yarkovsky effect and the dynamics of the solar system, doctoral thesis, Charles University, 2006).

Busch M.W. et al., Physical modeling of near-Earth asteroid 29075 (1950 DA). DPS Meeting, Pasadena, 2006.

Giorgini, J. D. et al., Asteroid 1950DA's encounter with Earth in 2880: Physical limits of collision probability prediction, Science 296, 132-136, 2002

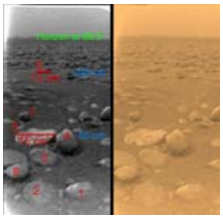
The TOP 5 !

Celebrating the 5 most important space missions of discovery in history !

Sputnik

Viking

Moon Landing



Titan landing

Voyager

LIMITED OFFER !

5 UNIQUE COLLECTIBLE DESIGN " T-SHIRTS " (only 300 available)

Our special package includes:

- **LIMITED EDITION COLLECTION OF 5 T-SHIRTS celebrating these 5 missions of discovery:**
  1. **Sputnik** - first satellite to orbit the Earth
  2. **Viking spacecraft** —first landing on Mars in 1976
  3. **Moon landing**— first manned landing on another world
  4. **Titan landing**—Huygens probe—first landing on the distant moon of Saturn
  5. **Voyager mission**- Spacecraft that visited more planets than any other

- **FREE TRITON FUN COFFEE MUG**
- **6 MONTH SUBSCRIPTION to the SCIENCE NEWSLETTER** (an $89.70 value)

** THIS SPECIAL PACKAGE NOW: **ONLY $100 !**

Only $100

(REGULAR VALUE $220.65)

ORDER NOW !

** These shirts will not be reprinted. Once our limited supply runs out, they are no longer available. —> Get these unique and beautiful shirts today ! <— **

ORDER ONLINE at: http://www.tritonfun.com

Call us at: 800-778-0560

E-mail: sales@tritonfun.com

Triton Fun Company
P.O. Box 1522
La Canada Flintridge, California 91012

Phone: 800-778-0560
E-mail: Science@tritonfun.com
Website: http://www.tritonfun.com

Mailing Address:

Triton Fun Company

Science and Astronomy-related products for the whole family

We're on the Web !
http://www.tritonfun.com

** Send us your superfluous questions for a future issue ! They can be on any subject. The funnier, the better. M.D., our editor, appreciates the help and will send you a free Triton Fun coffee mug as compensation for your question. Or write an article for us and be read by professional and amateur astronomers and scientists in the U.S. and Canada ! **

Superfluous Questions:

1. Where is the coldest permanently-inhabited village on Earth ?

   a) Iqaluit, Canada b) Oymyakon, Siberia c) Enontekio, Finland d) Attu, Aleutian Islands

2. What year did the Toronto Blue Jays play their first season of major league baseball ?

   a) 1982 b) 1977 c) 1985 d) 1979

3. Where is Hat Creek Observatory ?

   a) Massachusetts b) Australia c) England d) California

4. On what planet (in "Star Trek") did Spock fall in love (with a colonist at an agricultural colony) ?

   A) Camus 2 b) Gamma 7 c) Omicron Ceti 3 d) Alpha Carinae 2

—-> ANSWERS in next months issue of the Science Newsletter ! <——-

** ANSWERS to August's Superfluous Questions: 1. d) 5 2. c) Duke Ellington 3. c) Lagoon Nebula