Massachusetts Institute of Technology OpenCourseWare

8.03SC **Fall 2012**

Notes for Lecture #23: Farewell Special

This lecture consists of personal recollections, a musical performance, and advocacy of a way to put science into our daily lives for our enrichment. It is a fitting capstone to the course but does not contain any new material nor does it specifically refer to any of the topics covered in 8.03.

Prof. Lewin starts by describing his early work at MIT doing astronomy with X-rays. The power emitted by the sun in X-rays is only about 10^{-7} of the power in optical wavelengths. From this, it was not expected that X-ray sources would be found elsewhere in the sky. Surprisingly, sources were found with an X-ray to optical power ratio of 10^3. Prof. Lewin's early X-ray work was done with balloons to get above most of the atmosphere which strongly absorbs X-rays. To get enough lift in the thin upper atmosphere, the balloons need to be very large. At launch, they are inflated only partially because they expand enormously as they go from the dense atmospheric pressure at ground level to the observation level. They were launched from central Australia to have a long flight path that was over land but relatively free of other air traffic.

One discovery was that the power output could vary periodically with a time-scale of only a few minutes. It was very surprising that any astronomical object could vary with such a short period. These X-rays are emitted by neutron stars in binary systems where matter from the donor star falls onto the neutron star. Neutron stars have masses close to the Sun but very small radii ($\sim$10 km), so falling matter acquires a huge kinetic energy which is responsible for the X-rays. Neutron stars are created in the supernova explosion of stars with masses of about 10 solar masses or larger. Because of the large reduction in radius, these stars rotate very quickly and also have very large magnetic fields. The large field causes most of the falling matter to hit the neutron stars near the poles. The rotation of the star causes the "beam" of X-rays emitted from the poles to sweep across the sky, resulting in the observed periodicity. This research is currently done from satellites. One notable recent discovery was extremely fast ($\sim$few seconds) and very powerful (increases of factors of $\sim$10-20) bursts of X-rays. These are believed to originate in explosive run-away fusion of a thin surface layer of ^{4}He into carbon. These X-ray bursts heat the accretion disk of matter from the donor star and create optical bursts which have also been seen. Doppler shifts of light from these binary systems allow determination of the masses of the constituent stars.

At about (**1:05:00**), Prof. Lewin is serenaded by a student group with physics-inspired lyrics. He ends the lecture by encouraging students to appreciate seeing evidence of the concepts they have learned (the properties of rainbows, for example) throughout their daily lives.

8.03SC Physics III: Vibrations and Waves
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These viewing notes were written by Prof. Martin Connors in collaboration with Dr. George S.F. Stephans.