

General relativity versus exotic dark matter

Determinations of the rotation speed of stars in galaxies (galactic rotation curves) based on the assumption that Newtonian gravity is a good approximation have led to the inference that a large amount of dark matter must be present – more than can be accounted for by non-luminous baryonic matter. While there are plenty of attractive theoretical candidates for the additional dark matter, such as a lightest supersymmetric particle (LSP), it is also interesting to look into the details of the

calculations that suggest the need for such exotica. Now F I Cooperstock and S Tieu of the University of Victoria have reworked the problem using general relativity in place of Newtonian gravity, and they find no need to assume the existence of a halo of exotic dark matter to fit the observed rotation curves.

This is because even for weak fields and slow speeds, well-known nonlinearities change the character of the solution dramatically. The success of Newtonian mechanics in situations

like our solar system can be traced to the fact that in this case the planets are basically “test particles”, which do not contribute significantly to the overall field. However, in a galaxy this approximation is not a good one – all the rotating matter is also the source of the gravitational field in which everything rotates.

Further reading

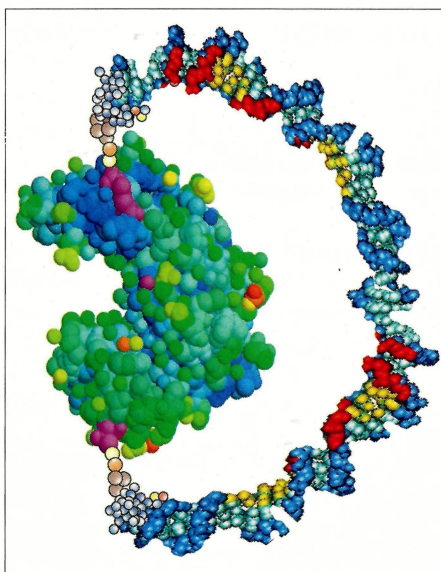
F I Cooperstock and S Tieu 2005
<http://xxx.lanl.gov/abs/astro-ph/0507619>.

Tiny ‘spring’ switches enzyme on and off

Enzymes are like nanomachines made out of proteins, and it can be very important medically to find ways to turn them on and off. Now Giovanni Zocchi in the Department of Physics and Astronomy and colleagues at the University of California, Los Angeles, have discovered a way to do this mechanically.

The researchers attached a “molecular spring” in the form of DNA to the enzyme guanylate kinase, coupling two parts of the protein (see figure). They were then able to change the stiffness of the spring by altering external DNA concentrations and so control the enzyme’s activity.

The action of guanylate kinase depends on its specific form, which the researchers compare to a vice, with the enzyme being active or “on” when the jaws of the vice come closer. By changing the stiffness of the spring, the team could control the mechanical tension between two points on the enzyme’s surface, and thereby open and close the jaws. Measurements of the activity of the enzyme, which catalyses phosphate transfer between certain macromolecules, then revealed that they could indeed turn the enzyme on and off reversibly. The net effect was chemical control of a single protein by mechanical means.



Model of the molecular structure of the enzyme, on the left, with the DNA spring attached. Changing the tension in the spring controls the distance between the “jaws” of the enzyme, and hence its activity.

Further reading

Brian Choi et. al. 2005 *Phys. Rev. Lett.* **95** 078102.

Hope for recreating the Hawking effect

Analogues of the Hawking effect are interesting, not least because they are in principle easier to realize than the genuine phenomenon, which needs a black hole. Ralf Schützhold of the Technische Universität, Dresden, and William G Unruh of the University of Victoria have recently suggested what may be the best candidate yet.

Inverting the fact that light propagating in a curved space-time can be thought of as propagating in a non-uniform index of refraction, they show that the propagation of electromagnetic waves of suitable wavelengths in an appropriate waveguide can be described in terms of an effectively curved space-time. The analogue of Hawking radiation should be just about measurable in microwaves with today’s technology and suggests a novel approach to studying this exotic effect in a model system. Among the insights that might be gained is some idea of what happens in the trans-Planckian regime.

Further reading

Ralf Schützhold and William G Unruh 2005 *Phys. Rev. Lett.* **95** 031301.

Nanotube used in liquid transistor

A new fluid-based transistor that controls the flow of aqueous ions has been constructed out of a silicon nanotube. Peidong Yang and

his colleagues from the University of California, Berkeley, used potassium chloride solution in a 15 μm -long nanotube as the equivalent of a channel in a field-effect transistor, with an external gold electrode playing the role of a gate.

The ability to control the flow of tiny numbers of charged molecules instead of the

usual flow of electrons could form the basis for a novel set of devices, running from computing elements through to sensitive chemical sensors.

Further reading

Rong Fan et. al. 2005 *Phys. Rev. Lett.* **95** 086607.

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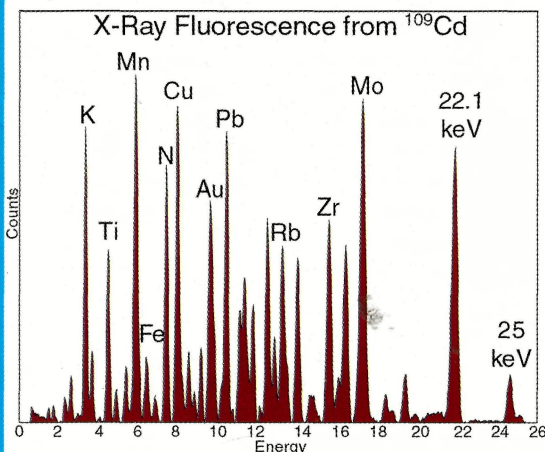
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X-Ray Detector

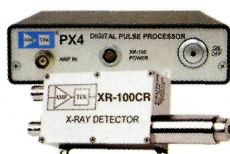
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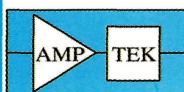


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