Web 2.0 technologies and their application to research environments

Stage topic description

The gradual evolution of the World Wide Web into what is now commonly called Web 2.0, created a lot of new opportunities and tools to manipulate, read and create information in an entirely new way. Social networks, blogs, wikis, semantic based technologies, all expanded the way common users relate and interact with the internet. Open source initiatives such as OpenAcademia [1], or the celebrated MIT SIMILE project [2] and many others have made these new technologies available to everybody.

Research communities are traditionally very keen on disseminating their results and ideas to the wider possible audience and to make use of innovative ways of doing so. The Advanced Concepts Team is no exception and its relation with Web 2.0 technologies has always been quite close.

Candidate's tasks

- Perform a review of all the open source available tools that may be used to foster the communication output of a research group such as the Advanced Concepts Team. These should include social networks, semantic technologies, tag clouds and others
- Experiment the integration of the most promising tools into the ACT way of performing and communicating everyday research results.
- Set up a google-scholar like environment for selected publications and link it to web 2.0 visualization tools.

Candidate's qualifications

- Web programming (DHTML, PHP, MySQL, JavaScript, AJAX, …)

References

[1] OpenAcademia (http://sourceforge.net/projects/openacademia/)
[2] SIMILE Project: Semantic Interoperability of Metadata and Information in unLike Environments (http://simile.mit.edu/)

Passive oscillation damping in booms inspired by plant stems

Stage topic Description

Oscillations are, in general, slow to be damp passively in absence of gravity and atmosphere. It can take up to two weeks following a spacecraft turning manoeuvre until the vibration has damped out. The performance of pointing and tracking systems can thus be severely affected by the presence of long mechanical booms. Practical countermeasures include active damping (using piezoelectric materials) or shaping the control command via input or command shaping [1] techniques.
Plant stems, on the other hand, have built in oscillation damping (or keeping, depending on the ecology) mechanisms resulting from a clever arrangement of the skeletal cells (sklerenchyme). Such an arrangement, or its working principle, could be mimicked and embedded in the very structure of satellites booms such as magnetometers or of solar panels, to give the overall structure a passive damping capability without introducing a mass penalty.

Candidate’s tasks

- Identify promising plants from previous work
- analyze the cross-sectional profile of these plants
- setup a FE model and simulate the loads of space manoeuvres
- take the most promising one and compare to state-of-the art solutions
- Effects of end mass (eg. flowers, scientific instruments)

Candidate's qualifications

- knowledge of plant anatomy
- biomechanics
- structural mechanics
- FE modelling

References

[1] Izzo, D. and Pettazzi, L., Command shaping for a flexible satellite platform controlled by advanced fly-wheels systems, Acta Astronautica, 60(10-11), pp.820-827, 2007.

Transport of nano-structured-materials in the interplanetary medium

Stage topic description

Interest from the nanotechnology community has been recently shown on the study of the pressure exerted by laser radiation on charged and uncharged particles [1-3]. Most of the efforts are focused on laser cooling, "laser pump" for isotope separation, and the trapping, confinement and manipulation of nanoparticles ("optical tweezers"), among many others. Employing these already-developed-models to study the dynamic behaviour of nanoparticles in the interplanetary medium, where the laser is replaced by sun radiation, is a challenging and attractive opportunity.

There is a large amount of data available on the effect of solar pressure on small particles (with dimensions from few molecules to 0.1 mm) [4]. However in the theoretical models developed for the study of such systems, there is a tendency to oversimplify the interaction terms in order to reduce the complexity of the many-body problem. Main objective is thus to asses the impact of more accurate models on a nanoparticle's orbit.

One of the applications is to study the transfer of material from one orbit to another making use of the solar pressure. More ambitiously, rare metals could also be transferred from asteroids to the Earth.

Candidate's tasks

- Make a bibliographic research on the key aspects of the models describing the pressure exerted by radiation on particles.
- Asses the impact of accurate models with respect to the models most commonly used to study debris disks and Saturn rings.
- Make a study on the force taking into account the size, the state of charge, the nature of the particles (dielectric or metallic particles) and eventually the shape, as this last parameter can be engineered to some extent.
- Choose a simple scenario to simulate the nanoparticle orbit to look for the material transfer from orbit to orbit. Example: transfer a particle from an orbit around the Earth to an orbit around the Moon.

Candidate's qualifications

- General knowledge of optics and material science.
- Being familiar with operative systems based on Linux and their development environment.
- Programing skills (preferably on fortran, c, python, and c++)

References

[1] V. Wong, M. A. Ratner, Phys. Rev. B 73, 075416 (2006)
[2] P. C. Chaumet, A. Rahmani, and M. Nieto-Vesperinas, Phys. Rev. B, **71**, 45425 (2005)
[3] J. R. Arias-González and M. Nieto-Vesperinas, J. Opt. Soc. Am. A **20**, 1201 (2003)
[4] E. Grün. Interplanetry Dust and the Zodiacal Cloud. In *Encyclopedia of the Solar System*, pages 673–696, (1999).

General Relativistic Effects in Multi-Satellite Systems

Stage topic description

While the derivation of the orbits of a single s/c (test-particle) in general relativity is rather straightforward, the extension to several objects (swarms, formations, tethered systems or similar) gives rise to considerable technical complications. This is due to the fact that a single s/c always can be looked at in its proper time, while this obviously does not apply to a system of s/c (the proper time of each s/c differs from the others.) This difference is not just source for technical complications, but also for interesting and sometimes surprising physical effects, as the investigation of systems with constraints showed [1-7]. Therefore, it would be interesting to extend activities and results from the ACT (in particular formation flying, but eventually also tethered systems) to the full theory of general relativity.

Candidate's tasks

- Extend models of formation flying to general relativity. Schwarzschild metric should be taken as a starting point, but in a second step the situation should be generalised to Kerr metric.
- Numerically analyse the effects of general relativity on special topics in formation flying, e.g. special inclinations.
- Optionally, the exact results could be compared with a systematic expansion (e.g. post-Newtonian expansion.)
- The analysis could be extended to systems including constraints, in particular tethered systems. This should in particular include an extension of the results in [1-7].

Candidate's qualifications

- Programming, numerical analysis (Fortran, Matlab, Maple).
- Good background in general relativity.

References

1. A. Shapere and F. Wilczek, "Self-propulsion at low Reynolds number," Phys. Rev. Lett. 58 (1987) 2051.
2. A. Shapere and F. Wilczek, "Geometry of self-propulsion at low Reynolds number," J. Fluid Mech. 198 (1989) 557.
3. A. Shapere and F. Wilczek, eds., *Geometric Phases in Physics*. World Scientific, 1989.
4. J. Wisdom, "Swimming in spacetime: motion by cyclic changes in body shape," Science 299 (2003) 2865.
5. E. Gueron, C. A. S. Maia, and G. E. A. Matsas, Swimming versus swinging in spacetime," Phys. Rev. D73 (2006) 024020, gr-qc/0510054.
6. E. Gueron and R. A. Mosna, "The relativistic glider," Phys. Rev. D75 (2007) 081501, gr-qc/0612131.
7. J. E. Avron and O. Kenneth, "Swimming in curved space or the baron and the cat," New J. Phys. 8 (2006) 68, math-ph/0602053.