

Suggested Topics for a 3<sup>rd</sup>-year Physics Project  
(2008/2009 Academic year)

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1. **BEYOND QUANTUM JUMPS: BLINKING NANO-SCALE LIGHT EMITTERS**

On the nanoscale, almost all light sources blink. Surprisingly, such blinking occurs on time scales much larger than predicted by quantum mechanics and has statistics governed by nonergodicity.

Reference: Stefani, Hoogenboom, and Barkai, *Physics Today* **62** (February 2009) p. 34.

URL: <http://link.aip.org/link/PHTOAD/v62/i2/p34/s1/pdf>

2. **WHEN FERMIONS BECOME BOSONS: PAIRING IN ULTRACOLD GASES**

The unprecedented control over the interactions and pairing of ultracold fermionic atoms provides insight into exotic strongly correlated phenomena and illuminates the physics of superfluidity in metals, nuclei, and neutron stars.

Reference: Sá de Melo, *Physics Today* **61** (October 2008) p. 45.

URL: <http://link.aip.org/link/PHTOAD/v61/i10/p45/s1/pdf>

3. **PROBING PHYSICAL PROPERTIES AT THE NANOSCALE**

With the interaction between a sharp tip and a surface tailored using combinations of static and time-dependent external fields, scanning probe techniques can image far more than topographic structure.

Reference: Brukman and Bonnell, *Physics Today* **61** (June 2008) p. 36.

URL: <http://link.aip.org/link/PHTOAD/v61/i6/p36/s1/pdf>

4. **THE PHYSICS OF PHAGES**

Experiments can measure, and theory explain, the energetics behind packaging a virus with DNA and the DNA's injection into a cell.

Reference: Gelbart and Knobler, *Physics Today* **61** (January 2008) p. 42.

URL: <http://link.aip.org/link/PHTOAD/v61/i1/p42/s1/pdf>

5. **THE DIVERSE WORLD OF LIQUID CRYSTALS**

Orientationally ordered soft matter is exceptionally responsive to a variety of excitations. That's the basis for its great range of applications.

Reference: Palfy-Muhoray, *Physics Today* **60** (September 2007) p. 54.

URL: <http://link.aip.org/link/PHTOAD/v60/i9/p54/s1/pdf>

6. **GRAPHENE: EXPLORING CARBON FLATLAND**

Just one atom thick, this two-dimensional semiconductor does not resemble any known material.

Reference: Geim and MacDonald, *Physics Today* **60** (August 2007) p. 35.

URL: <http://link.aip.org/link/PHTOAD/v60/i8/p35/s1/pdf>

7. **CRUMPLING, BUCKLING, AND CRACKING: ELASTICITY OF THIN SHEETS**

Deforming thin surfaces creates a rich set of structural and dynamical problems combining physics and geometry.

Reference: Marder, Deegan, and Sharon, *Physics Today* **60** (February 2007) p. 33.

URL: <http://link.aip.org/link/PHTOAD/v60/i2/p33/s1/pdf>

8. **CASIMIR FORCES: STILL SURPRISING AFTER 60 YEARS**  
The once startling idea of a connection between quantum fluctuations and forces has by now been applied throughout physics. Nonetheless, experimentalists and theorists alike still find challenges in the Casimir force.  
Reference: Lamoreaux, *Physics Today* **60** (February 2007) p. 40.  
URL: <http://link.aip.org/link/PHTOAD/v60/i2/p40/s1/pdf>
9. **PUTTING MECHANICS INTO QUANTUM MECHANICS**  
Nanoelectromechanical structures are starting to approach the ultimate quantum mechanical limits for detecting and exciting motion at the nanoscale. Nonclassical states of a mechanical resonator are also on the horizon.  
Reference: Schwab and Roukes, *Physics Today* **58** (July 2005) p. 36.  
URL: <http://link.aip.org/link/PHTOAD/v58/i7/p36/s1/pdf>
10. **REVERSING LIGHT WITH NEGATIVE REFRACTION**  
Materials engineered to have negative permittivity and permeability demonstrate exotic behavior, from a negative refractive index to subwavelength focusing.  
Reference: Pendry and Smith, *Physics Today* **57** (June 2004) p. 37.  
URL: <http://link.aip.org/link/PHTOAD/v57/i6/p37/s1/pdf>
11. **LOCALIZING ENERGY THROUGH NONLINEARITY AND DISCRETENESS**  
Intrinsic localized modes have been theoretical constructs for more than a decade. Only recently have they been observed in physical systems as distinct as charge-transfer solids, Josephson junctions, photonic structures, and micromechanical oscillator arrays.  
Reference: Campbell, Flach, and Kivshar, *Physics Today* **57** (January 2004) p. 43.  
URL: <http://link.aip.org/link/PHTOAD/v57/i1/p43/s1/pdf>
12. **MOLECULAR ELECTRONICS**  
Improvements in our understanding of how molecules transport charge, and how they interface to the macroscopic world, are fueling new devices and applications.  
Reference: Heath and Ratner, *Physics Today* **56** (May 2003) p. 43.  
URL: <http://link.aip.org/link/PHTOAD/v56/i5/p43/s1/pdf>
13. **QUANTUM CASCADE LASERS**  
Band-structure engineering has led to a fundamentally new laser with applications ranging from highly sensitive trace-gas analysis to communications.  
Reference: Capasso, Gmachl, Sivco, and Cho, *Physics Today* **55** (May 2002) p. 34.  
URL: <http://link.aip.org/link/PHTOAD/v55/i5/p34/s1/pdf>
14. **THE LITTLE MACHINES THAT ARE MAKING IT BIG**  
Microelectromechanical systems are currently used in a variety of applications, including triggering airbags and measuring the Casimir force. In the future, they may revolutionize the way we think about machines.  
Reference: Bishop, Gammel, and Giles, *Physics Today* **54** (October 2001) p. 38.  
URL: <http://link.aip.org/link/PHTOAD/v54/i10/p38/s1/pdf>