“Topological Superconductivity and High Chern Numbers in 2D Ferromagnetic Shiba Lattices”
Joel Röntynen and Teemu Ojanen
Phys. Rev. Lett. 114, 236803 (2015)

“Majorana Zero Modes in Graphene”
P. San-Jose, J. L. Lado, R. Aguado, F. Guinea, J. Fernández-Rossier
arXiv:1506.04961

The realisation of topological superconductivity (TS), a novel electronic phase characterised by Majorana excitations, has become a major goal in modern condensed matter research. Despite promising experimental progress on a number of appealing implementations, a conclusive proof of TS remains an open challenge. We here report on a new approach to obtain TS and Majorana states in graphene/superconductor junctions. Key to our proposal is the interaction-induced magnetic ordering of graphene's zero Landau level (ZLL). Coupling this unique state to a conventional superconductor gives rise to novel edge states whose properties depend on the type of magnetic order. In particular, the canted antiferromagnetic phase is a natural host for Majorana bound states. Our proposal combines effects that were recently demonstrated experimentally (tuneable spin ordering of the ZLL and graphene/superconductor junctions in the Quantum Hall regime that exhibit highly ballistic transport), and is thus ready to be tested.

“Universal decoherence due to gravitational time dilation”
I. Pikovski, M. Zych, F. Costa & Č. Brukner
Nature Physics (2015) doi:10.1038/nphys3366

The physics of low-energy quantum systems is usually studied without explicit consideration of the background spacetime. Phenomena inherent to quantum theory in curved spacetime, such as Hawking radiation, are typically assumed to be relevant only for extreme physical conditions: at high energies and in strong gravitational fields. Here we consider low-energy quantum mechanics in the presence of gravitational time dilation and show that the latter leads to the decoherence of quantum superpositions. Time dilation induces a universal coupling between the internal degrees of freedom and the centre of mass of a composite particle. The resulting correlations lead to decoherence in the particle position, even without any external environment. We also show that the weak time dilation on Earth is already sufficient to affect micrometre-scale objects. Gravity can therefore account for the emergence of classicality and this effect could in principle be tested in future matter-wave experiments.

“Optical Polarization of Nuclear Spins in Silicon Carbide”
A. L. Falk, P. V. Klimov, V. Ivády, K. Szász, D. J. Christle, W. F. Koehl, Á. Gali, and David D. Awschalom
Phys. Rev. Lett. 114, 247603 (2015)

We demonstrate optically pumped dynamic nuclear polarization of Si29 nuclear spins that are strongly coupled to paramagnetic color centers in 4H- and 6H-SiC. The 99%±1% degree of polarization that we observe at room temperature corresponds to an effective nuclear temperature of 5 μK. By combining *ab initio* theory with the experimental identification of the color centers’ optically excited states, we quantitatively model how the polarization derives from hyperfine-mediated level anticrossings. These results lay a foundation for SiC-based quantum memories, nuclear gyroscopes, and hyperpolarized probes for magnetic resonance imaging.

“Impurity-Induced Bound States in Superconductors with Spin-Orbit Coupling”
Y. Kim, J. Zhang, E. Rossi, and R. M. Lutchyn
Phys. Rev. Lett. 114, 236804 (2015)

We study the effect of strong spin-orbit coupling (SOC) on bound states induced by impurities in superconductors. The presence of SOC breaks the SU(2)-spin symmetry and causes the superconducting order parameter to have generically both singlet (s-wave) and triplet (p-wave) components. We find that in the presence of SOC the spectrum of Yu-Shiba-Rusinov (YSR) states is qualitatively different in s-wave and p-wave superconductors, a fact that can be used to identify the superconducting pairing symmetry of the host system. We also predict that, in the presence of SOC, the spectrum of the impurity-induced bound states depends on the orientation of the magnetic moment S of the impurity and, in particular, that by changing the orientation of S, the fermion-parity of the lowest energy bound state can be tuned. We then study the case of a dimer of magnetic impurities and show that, in this case, the YSR spectrum for a p-wave superconductor is qualitatively very different from the one for an s-wave superconductor even in the limit of vanishing SOC.

“Rydberg Electrons in a Bose-Einstein Condensate”
Jia Wang, Marko Gacesa, and R. Côté
Phys. Rev. Lett. 114, 243003 (2015)

We investigate a hybrid system composed of ultracold Rydberg atoms immersed in an atomic Bose-Einstein condensate (BEC). The coupling between Rydberg electrons and BEC atoms leads to excitations of phonons, the exchange of which induces a Yukawa interaction between Rydberg atoms. Because of the small electron mass, the effective charge associated with this quasiparticle-mediated interaction can be large. Its range, equal to the BEC healing length, is tunable using Feshbach resonances to adjust the scattering length between BEC atoms. We find that for small healing lengths, the distortion of the BEC can “image” the Rydberg electron wave function, while for large healing lengths the induced attractive Yukawa potentials between Rydberg atoms are strong enough to bind them.

“Coherent manipulation of a Majorana qubit by a mechanical resonator”
P. Zhang, Franco Nori
arXiv:1506.05879

We propose a hybrid system composed of a Majorana qubit and a mechanical resonator, implemented by a semiconductor nanowire in proximity to an s-wave superconductor. In this proposal, three ferromagnetic gates are placed on top of and along the nanowire; the two outer gates are static and the inner one is free to oscillate harmonically as a mechanical resonator. These ferromagnetic gates induce a local Zeeman splitting and give rise to four Majorana bound states, constituting a Majorana qubit in the nanowire. The dynamical hybridization of the Majorana bound states, arising from the motion of the oscillating gate, results in a coherent coupling between the Majorana qubit and the mechanical resonator. By tuning the electric voltage on the ferromagnetic gates to modulate the local Rashba spin-orbit coupling, it is possible to reach the resonance of the two quantum systems for relatively strong couplings.

“Conductance spectroscopy of a proximity induced superconducting topological insulator”
M. Snelder, M. P. Stehno, A. A. Golubov, C. G. Molenaar, T. Scholten, D. Wu, Y. K. Huang, W. G. van der Wiel, M. S. Golden, A. Brinkman
arXiv:1506.05923

We study the proximity effect between the fully-gapped region of a topological insulator in direct contact with an s-wave superconducting electrode (STI) and the surrounding topological insulator flake (TI) in Au/Bi1.5Sb0.5Te1.7Se1.3/Nb devices. The conductance spectra of the devices show the presence of a large induced gap in the STI as well as the induction of superconducting correlations in the normal part of the TI on the order of the Thouless energy. The shape of the conductance modulation around zero-energy varies between devices and can be explained by existing theory of s-wave-induced superconductivity in SNN' (S is a superconductor, N a superconducting proximized material and N' is a normal metal) devices. All the conductance spectra show a conductance dip at the induced gap of the STI.

“Interplay of Electron and Nuclear Spin Noise in GaAs”
F. Berski, J. Hübner, M. Oestreich, A. Ludwig, A. D. Wieck, M. Glazov
arXiv:1506.05370

“Imprint of topological degeneracy in quasi-one-dimensional fractional quantum Hall states”
Eran Sagi, Yuval Oreg, Ady Stern, and Bertrand I. Halperin
Phys. Rev. B 91, 245144 (2015)

“Topological Superconductors and Category Theory”
Andrei Bernevig, Titus Neupert
arXiv:1506.05805

“Magnetic chains on a triplet superconductor”
P.D. Sacramento
arXiv:1506.05249

“Detection of topological states in two-dimensional Dirac systems by the dynamic spin susceptibility”
Masaaki Nakamura, Akiyuki Tokuno
arXiv:1506.04691

“Solving strongly correlated electron models on a quantum computer”
Dave Wecker, Matthew B. Hastings, Nathan Wiebe, Bryan K. Clark, Chetan Nayak, Matthias Troyer
arXiv:1506.05135