The research strategy of the Quantum Information Group is to investigate the possibilities for quantum information processing via several key routes, all of which are radically new and challenging.

Endohedral fullerenes are hollow, cage-like carbon molecules with one or more atoms encapsulated inside them. Their electronic properties make these molecules attractive for quantum nano-electronic applications.

In the QIP group, we have a very strong track record of research on molecular structures based on fullerenes including the synthesis and purification of novel endohedral fullerenes such as $^{15}\text{N}@@\text{C}_{60}$ which has been obtained at high purity (> 95%) for the first time. We measured the longest ever coherence time for a molecular qubit embodied in N@C$_{60}$ ($T_2=0.24$ milliseconds at 160 K) and we performed single qubit operations using pulsed Electron Paramagnetic Resonance (EPR). We have developed error-measuring algorithms and applied error-correcting sequences to produce high-fidelity single qubit gates [1].

We have synthesized novel types of endohedral fullerenes, including a previously undiscovered bimetallic endohedral fullerene containing two Pr ions. We have comprehensively characterized this fullerene using mass spectrometry, NMR spectroscopy and high resolution TEM. This work paves the way for a whole family of bimetallic endohedral fullerenes in useful quantities [2, 3].

We have studied the photoluminescence for the endohedral metallofullerenes Er$_2$@C$_{82}$ (isomer I) and Er$_3$C$_2$@C$_{82}$ (isomer I) at low temperature. The emission arising from Er$_2$C$_2$@C$_{82}$ (I) appears acuminate when compared with that of Er$_2$@C$_{82}$ (I). The Er$_2$C$_2$@C$_{82}$ (I) emission linewidths are comparable to those found in crystals, making this molecule of interest for applications where accessible, well-defined quantum states are required [4].

High-accuracy mass spectrometry is a key characterisation technique for the materials presented above and we have been using it extensively to elucidate the structure of endohedral fullerenes and their derivatives (Fig.1).

![Molecular model of Er$_2$C$_2$@C$_{82}$ (isomer I). The trapped Er ions and the C$_2$ group are shown schematically as green and purple, respectively. The inset shows the mass spectrum of Er$_2$C$_2$@C$_{82}$ obtained using matrix-assisted laser desorption time-of-flight (MALDI-TOF) mass spectrometry analysis with negative ionization and DCTB as matrix.](image)

References