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Climbing the rotational ladder to chirality

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Chirality is conventionally associated with a chemical or optical property of a molecule being in either of its two enantiomeric (mirror-image) forms. In a more general sense, chirality is determined by the time and space inversion (PT) symmetry of the system. Chiral molecules are 'born'to be so, owing to their quasi-rigid spatially enantiomorphic geometrical structures with high potential energy barriers between the enantiomers. That said, it is possible to induce and modulate chirality in statically non-chiral molecules. For example, by forcing a molecule to rotate coherently in one direction, i.e., to possess a well-defined helicity, we can create a chiral entity. Phosphine (PH3) is an excellent example: at high rotational excitation it forms well separated near degenerate rotational cluster states where the molecule undergoes stable rotation around one of its P-H bonds in a clockwise or anti-clockwise manner [1,2]. This is analogous to a system with static chirality: oppositely rotating forms are energetically indistinguishable from each other and are separated by a high (kinetic) energy barrier.
We will present robust, quantum mechanical simulations of the experimental methods for creating rotational cluster states in PH3 [3] (e.g., using an optical centrifuge [4,5]), techniques for spatial separation [6] of the dynamically chiral enantiomers, as well as perspectives for detecting chirality using modern experiments [7,8,9].

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