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Non-Abelian quantum Hall states of fermions and bosons[1]

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In a non-Abelian quantum Hall state, there are types of elementary excitations or quasiparticles that obey non-Abelian statistics. This is an extension of the idea of fractional statistics that means that when several of these quasiparticles are present in the system and are well-separated at well-defined positions, there is a degenerate space of lowest-energy states. When the quasiparticles are then exchanged adiabatically, the result is a matrix operation on this space of states. Greg Moore and the author[1] introduced this idea to condensed matter physics in 1991. They proposed a basic example called the Moore-Read Pfaffian state. The physics of the existence of the degenerate states for the quasiparticles in this system can be understood by viewing it as a $p_x - ip_y$ paired state of composite fermions, in which quasiparticles are $hc/2e$ vortices that carry Majorana fermion zero modes. This state is expected to be realized in the filling factor $\nu = 5/2$ fractional quantum Hall (FQH) state. In later work, a series (labeled by an integer k) of "parafermion" states was proposed[2]. This talk will review these ideas, and describe recent numerical work that strongly supports the idea that the $k = 3$ member of the sequence occurs in the filling factor 12/5 FQH state for electrons[3], and also[4] in a system of bosons, such as rotating cold atoms, at filling factor 3/2. It will also describe recent analytical results[5] on the explicit quasihole trial wavefunctions of the parafermion states.

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2. N. Read and E. Rezayi, Phys. Rev. B **59**, 8084 (1999).
3. E.H. Rezayi and N. Read, cond-mat/0608346.
4. E.H. Rezayi, N. Read, and N.R. Cooper, Phys. Rev. Lett.**95**, 160404 (2005).
5. N. Read, Phys. Rev. B **73**, 245334 (2006).

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