On the Construction of Asymmetric Quantum Error-Correcting Codes

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Quantum error-correcting codes were introduced to protect quantum information from decoherence and quantum noise. Ever since their introduction in the mid 1990's, much progress has been made on their construction. A rather prevalent idea that has proved to be very useful is to construct quantum codes using classical error-correcting block codes.

More recently, it was also established from experiments that, in many quantum systems, phase-flip errors happen more frequently than bit-flip errors. Asymmetric quantum error-correcting codes, which take advantage of this asymmetry, have been introduced as a result (as opposed to the more established symmetric ones which do not distinguish between these two types of errors).

As in the case for classical error-correcting block codes, there are known bounds constraining the parameters of quantum codes. One such bound is the quantum Singleton bound, and the codes whose parameters satisfy this bound are known as maximum distance separable (MDS) quantum codes. An interesting problem is to construct optimal quantum codes, in the sense that codes of better parameters can be proved not to exist. Of course, a code that attains some known bound on the parameters is therefore naturally optimal.

In this talk, we will focus on the construction of optimal asymmetric quantum codes using suitable classical error-correcting block codes, via purely mathematical approaches (i.e., no physics!). In particular, many MDS quantum codes and some other optimal ones are constructed. No pre-requisite knowledge of error-correcting codes will be assumed. Essential ideas and facts in coding theory will be introduced.