California State University, Long Beach

# THE MATHEMATICS COLLOQUIUM

presents


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speaking on

## Low-Density Parity-Check Codes and the Sum-Product Algorithm

**Friday, December 1, 2006** **12:00PM-1:00PM**

**FO3-200A**


**Abstract**: This talk will present work in progress with John Brevik (CSULB) and Rich Wolski (UCSB) on a delightfully simple algorithm that is surprisingly difficult to analyze.

The context is coding for error-correction, which is used in numerous communications systems, such as cell phones, satellites, and CD players. In the 1990's, coding theorist resurrected an idea that had lain dormant since the early years of the subject, Gallagher's low-density parity-check (LDPC) codes. An LDPC code is the nullspace of a sparse binary matrix. The "delightfully simple algorithm" used to decode LDPC codes—called the sum-product algorithm (SPA for acronym lovers)—is based on the distributive law, $a(b+c) = ab+ac$. What could be simpler! The SPA is often called a "message passing algorithm" since it can be visualized by imagining messages passed along the edges of the bipartite graph associated to the matrix defining the code. When the bipartite graph is a tree, the algorithm stabilizes to a value which is simple to establish theoretically. When the the graph is not a tree the error-correction performance varies from excellent to abysmal, depending on the choice of binary matrix. Although there are heuristics for choosing good matrices, the causes of decoding success and failure remain a mystery.

The talk will start with the fundamentals of error-correction using LDPC codes, and end with our algebraic analysis and experimental results of the algorithm on small graphs. It should be accessible to a broad audience.