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The Gauss-Wilson Theorem for Partial Products

For positive integers $M \geq 2$ and $n \equiv 1 \pmod M$ we define the *Gauss factorial* $(\frac{n-1}{M})_n!$ to be the product of all integers up to $\frac{n-1}{M}$ and relatively prime to n, a terminology suggested by Gauss's generalization of Wilson's theorem. While the multiplicative orders (mod n) of Gauss factorials are completely determined when $M = 2$, the general case presents numerous interesting challenges. After some general results, this talk will concentrate on the special cases $M = 3$ and $M = 4$. The binomial coefficient theorems of Gauss and Jacobi are important tools, as are certain Pell equations and their solutions. Some large-scale computations are also involved. (Joint work with John B. Cosgrave.)