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3. Number Theory and Arithmetic Algebraic Geometry

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Number of Points of Singular Varieties over Finite Fields

Let X be a projective algebraic subvariety of $\mathbb{P}^N$ of dimension n defined over the finite field $\mathbb{F}_q$ of q elements. In case X is a nonsingular complete intersection, we have a sharp estimate for $|X(\mathbb{F}_q)|$ due to Deligne (1981). This was extended to the singular case by Hooley and Katz (1991). We obtain a refinement of the latter by proving a precise inequality for $||X(\mathbb{F}_q)| - \pi_n|$, where π_n denotes $|\mathbb{P}^n(\mathbb{F}_q)| = q^n + q^{n-1} + \cdots + 1$. The proof is primarily based on a suitable generalization to singular varieties of the Weak Lefshetz Theorem together with some Bertini-type arguments and the Grothendieck-Lefshetz Trace Formula. In the process, we also obtain a sharper version of the classical Lang-Weil inequality.