

Interesting Topological Spaces in Algebraic Geometry

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Contents

1	Ideas for Spaces	1
2	Analogies	2

1 Ideas for Spaces

- Curves
 - Elliptic Curves
 - Higher genus
 - Hyperelliptic curves
 - The modular curve
- Surfaces
 - Compact Riemann surfaces
 - * Bolza Surface (Genus 2)
 - * Klein Quartic (Genus 3)
 - * Hurwitz Surfaces
 - Kummer surfaces
- Compact Complex Surfaces
 - Rational ruled
 - Enriques Surfaces
 - $K3$
 - * Kahler Manifolds
 - Kodaira
 - Toric
 - Hyperelliptic
 - Properly quasi-elliptic
 - General type
 - Type VII
- Fake projective planes
- Conics
- Calabi-Yau manifolds
 - Dimension 1: All elliptic curves (up to homeomorphism)

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- Dimension 2: $K3$ surfaces
 - Dimension 3 (threefolds): 500 million +, unknown if infinitely many
 - The bananafold
 - Hyperkähler
 - Hurwitz schemes
 - Topological galois groups, e.g. $G(\bar{F}/F)$ for $F = \mathbb{Q}, \mathbb{F}_p$.
 - $\text{Spec}(R)$ for R a DVR (a Sierpinski space)
 - Quiver Grassmannians
 - Rigid analytic spaces
 - Affine line with two origins
 - Moduli stack of elliptic curves $\mathcal{M}_{1,1}$.
 - Abelian Surface
 - Fano Varieties
 - Curves: isomorphic to \mathbb{P}^1
 - Surfaces: Del Pezzo surfaces
 - Weighted projective space
 - Toric Varieties
 - Grassmannian
 - Flag Varieties
 - Moduli Spaces

Due to Kunihiko Kodaira's classification of complex surfaces, we know that any compact hyperkähler 4-manifold is either a $K3$ surface or a compact torus T^4 . (Every Calabi–Yau manifold in 4 (real) dimensions is a hyperkähler manifold, because $SU(2)$ is isomorphic to $Sp(1)$.)

As was discovered by Beauville, the Hilbert scheme of k points on a compact hyperkähler 4-manifold is a hyperkähler manifold of dimension $4k$. This gives rise to two series of compact examples: Hilbert schemes of points on a $K3$ surface and generalized Kummer varieties.

2 Analogies

- 2-manifolds: Uniformization
 - Simply connected Riemann surfaces are conformally equivalent to one of $\mathbb{H}, \mathbb{D}^\circ, \mathbb{CP}^1$.
- 3-manifolds: Thurston's Geometrization
 - Oriented prime 3-manifolds can be decomposed into geometric “pieces” of 8 possible types
 - Geometric structure: a diffeo $M \cong \tilde{M}/\Gamma$ where Γ is a discrete Lie group acting freely/transitively on X