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Obstructing Stein structures on contractible 4-manifolds

A Stein manifold is a complex manifold with particularly nice convexity properties. In real dimensions above 4, existence of a Stein structure is essentially a homotopical question, but for 4-manifolds the situation is more subtle. We will show that there exist homotopically trivial smooth 4-manifolds that do not admit Stein structures, answering a question that has circulated among contact and symplectic topologists recently. Along the way we will provide new evidence for a conjecture of Gompf, which asserts that a nontrivial Brieskorn homology sphere cannot be embedded in complex 2-space as the boundary of a Stein submanifold.