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Non-Perturbative Superpotentials in Heterotic String Theory

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Abstract:

We study the non-perturbative superpotential in $E_8 \times E_8$ heterotic string theory on a non-simply connected Calabi-Yau
manifold X, as well as on its simply connected covering space $\tilde{X}$.
The superpotential is induced by the string wrapping holomorphic, isolated, genus 0 curves.
According to the residue theorem of Beasley and Witten, the non-perturbative superpotential must vanish in a large class
of heterotic vacua because the contributions from curves in the same homology class cancel each other.
We point out, however, that in certain cases the curves treated in the residue theorem as lying in the same homology class, can actually be in different homology classes with respect to the physical Kahler form.
In these cases, the residue theorem is not directly applicable and the structure of the superpotential is more subtle.
We show, in a specific example, that the superpotential is non-zero both on $\tilde{X}$ and on X.
On the non-simply connected manifold X, we explicitly compute the leading contribution to the superpotential
from all holomorphic, isolated, genus 0 curves with minimal area. The reason for the non-vanishing of the superpotental on X is that the second homology class
contains a finite part called discrete torsion. As a result, the curves with the same area are distributed among different torsion classes
and, hence, do not cancel each other.

Author: Prof. OVRUT, Burt (University of Pennsylvania)

Presenter: Prof. OVRUT, Burt (University of Pennsylvania)

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