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**Yakov I Berchenko-Kogan\*** (yashabk@math.mit.edu). *Yang-Mills Replacement*. Preliminary report.

Harmonic replacement is a technique for reducing the energy of a map  $u: \Sigma^2 \rightarrow M$  by replacing it on a small ball  $B^2$  with a harmonic map  $v: B^2 \rightarrow M$  with the same values on the boundary as  $u$ . Harmonic replacement has proven to have a wide range of applications, such as the Perron method for constructing global harmonic functions, and, more recently, Colding and Minicozzi's proof of the finite extinction of Ricci flow on homotopy 3-spheres. We develop an analogous technique for Yang-Mills connections on 4-manifolds, where we replace a connection  $A$  on a small 4-ball  $B^4$  with a Yang-Mills connection  $B$  that has the same restriction to the boundary as  $A$ , thereby decreasing the energy. In both settings, the maps  $u$  and connections  $A$  are assumed to be  $L_1^2$ , not necessarily continuous, leading to subtleties involving borderline Sobolev spaces. It is hoped that this Yang-Mills replacement technique could be used to simplify the proofs in Taubes's work on the stable topology of the moduli spaces of anti-self-dual connections, as well as to provide a simpler alternative to Yang-Mills gradient flow in certain applications. (Received September 15, 2015)