

# Limits of the circles-in-the-sky searches in the determination of cosmic topology

Marcelo J. Rebouças  
Centro Brasileiro de Pesquisas Físicas,  
22290-180 Rio de Janeiro – RJ, Brasil

An important observable signature of a detectable nontrivial spatial topology of the Universe is the presence in the cosmic microwave background sky of pairs of matching circles with the same distributions of temperature fluctuations up to a phase — the so-called circles-in-the-sky. In all the attempts to find these circles, including the ones undertaken by Planck Collaboration, no matching circles were found. We discuss the question as to whether there are nearly flat universes, satisfying Planck constraints on cosmological parameters, with compact topology that would give rise to circles whose observable parameters (radii and relative positions of the circles) fall outside the ranges explored by the searches so far undertaken. We show that no matter how nearly flat the Universe is, it can always have a nontrivial spatial topology that gives rise to circles whose observable parameters has not been covered by the searches so far executed. This makes apparent that circles-in-the-sky searches carried out so far are not sufficient to exclude the possibility of a universe with detectable nontrivial topology with cosmological parameters are within the Planck bounds. We also discuss the unavoidable practical limits of the circles-in-the-sky topological signatures for circles with radii smaller than  $5^\circ$ .