

## Polychromatic 4-coloring of an even-sided embedding

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A vertex  $k$ -coloring  $c$  of a graph  $G$  on a surface is *polychromatic* if all  $k$  colors appear on the boundary vertices of each face of  $G$ . Horev et al. proved that every 3-regular simple bipartite plane graph has a polychromatic proper 4-coloring. By Kobayashi et al., this theorem has been extended to simple 3-regular even-sided embeddings on the projective plane. We generalize the results for the torus and the Klein bottle by using generating theorems of simple 3-regular even-sided embeddings with respect to some transformations.

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