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Classical drawings of branched coverings

Given a branched covering $\varphi\colon S^3 \to (S^3, k)$, it is an interesting and very difficult problem to determine the link type of $\varphi^{-1}(k) \subset S^3$. If k is drawn in an n-bridge presentation, that is, if there is a 3-ball $B \subset S^3$ such that k is the union of n properly embedded arcs in B and n arcs on ∂B, it is tempting to try to recover $\varphi^{-1}(k)$ from a drawing of $\varphi^{-}1(B)$—an abstract drawing, not an embedding of $\varphi^{-1}(B)$ in S^3. It is well known that, if $\varphi^{-1}(B)$ is also a 3-ball, this is possible. If $\varphi^{-1}(B)$ is a handlebody of positive genus, an arbitrary drawing of $\varphi^{-1}(B)$ is generally misleading.

We give a description of how to embed $\varphi^{-1}(B)$ in S^3 in the general case, and, therefore, a complete criterion to recover the link type of $\varphi^{-1}(B)$ from an embedding of $\varphi^{-1}(B)$ in S^3. We also give some applications.