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Big polygon spaces produce maximal syzygies in equivariant cohomology

Let $T = (S^1)^r$ be a torus. We present a new class of compact orientable T-manifolds, called "big polygon spaces". Like polygon spaces, which appear as their fixed point sets, they depend on a length vector $\ell \in \mathbb{R}^r_{\geq 0}$. Although the equivariant cohomology of a big polygon space $X(\ell)$ is never free over $H^*(BT)$, one can observe interesting phenomena for suitable ℓ. In particular, $H^*_T(X(\ell))$ can be descibed by the "GKM method", and the equivariant Poincaré pairing for X can be perfect. The existence of such T-manifolds was unknown so far. More generally, $H^*_T(X(\ell))$ can be a syzygy of any order less than $r/2$ over $H^*(BT)$, which shows that a bound on the syzygy order obtained by Allday–Franz–Puppe is sharp.