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Lens Prior Matching with Latent Diffusion Models

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Latent Diffusion Models (LDMs) have achieved remarkable success in various domains of generative modeling, particularly due to their ability to efficiently learn and represent complex data distributions in an abstract latent space. This success is exemplified by their use in Stable Diffusion or FLUX.1, state-of-the-art text-to-image synthesis techniques that leverage the strengths of LDMs to generate detailed natural images from noise (guided by text prompts).

Here, we present our ongoing work on LDMs for prior matching lensing galaxies. Strong gravitational lensing represents an ill-posed inverse problem which is why it is crucial to have tight physical constraints on a given observation to narrow down the solution space. This is often the sole focus of parametric lens modelling studies, but such models lack physical grounding and ignore knowledge about galaxy formation and evolution. We propose a novel data-driven approach which uses generative deep learning to match the prior distribution. By training LDMs on galaxies from (magneto-)hydrodynamical large-scale simulations, we can guide the lens inference process, leading to more accurate, robust, and most importantly physical free-form lens reconstructions. Finally, we demonstrate our approach on recent lens discovery J1721+8842: the fist Einstein zig-zag lens.

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