# Investigating the Influence of Asymmetric Error Bars in Retrievals of Exoplanet Transmission Spectra

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**Abstract**

In a Bayesian retrieval framework, the goodness-of-fit of a model to the observed data is quantified by computing the value of a likelihood function. This informs the pipeline of the suitability of the tested parameters and iteratively updates the system's knowledge in response. However, current pipelines assume a Gaussian form of the likelihood which imposes limitations on our analysis.

Many datasets have now been published which exhibit different upper and lower error bars. These emerge from the asymmetric form of the posterior distributions when fitting the transit depths across wavelength channels in lightcurve data. The Gaussian likelihood can only accept one value for the width of the distribution and, as such, we are forced to average between the two quoted errors. The extent to which this approximation could influence the resultant predictions has been given little attention up to this point. Perhaps it was safe in an age of lower quality data but we have now become sensitive to its influence with improved observing capabilities with the James Webb Space Telescope (JWST).

Given that many JWST datasets are now available to the community, we test this assumption and seek to reaffirm our confidence in our predictions. We incorporate an asymmetric likelihood function in a retrieval and test its ability to accurately retrieve the parameters of a simulation scattered by an asymmetric distribution. Results are compared to the currently accepted, Gaussian case in several scattering regimes and, in doing so, we are able to probe the retrieval's sensitivity to this effect at different scales.

On data scattered by realistic error bars (in terms of their scale and the level of asymmetry), we find the Gaussian assumption to be sufficient. However, when we test the retrieval's sensitivity to these effects with extreme cases of asymmetry, we find that we can improve on the Gaussian approximation as long as the exact shape of the error distribution is well known.