# Constraining Stellar Binarity with VRO LSST Observations

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The Legacy Survey of Space and Time at the Vera Rubin Observatory will create a vast and impactful database of wide-area, deep photometry. In addition to its primary goal of observing transient events through time series data, it will also produce deep images of galaxies spanning a wide range of cosmic time.

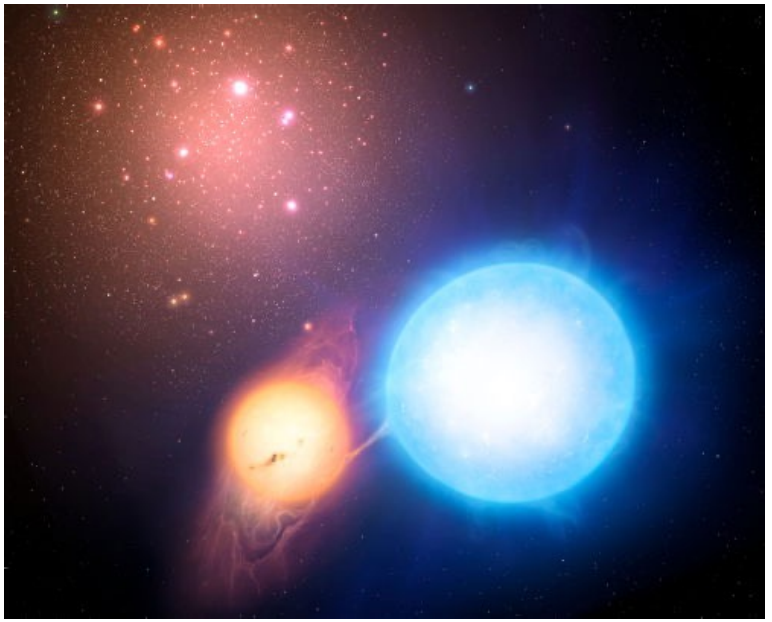

Image: Mark A Garlick / University of Warwick

Inevitably interpreting those observations requires comparison with stellar population models, whether these are used to interpret the frequency and properties of individual stars (or stellar transients) within a population, or used to characterise the integrated light from unresolved, extragalactic stellar systems.

The Binary Population and Spectral Synthesis (BPASS) models (Eldridge et al 2017, Stanway & Eldridge 2018) are now widely used for interpreting high redshift and young stellar populations. Crucially, they are built on stellar evolution models that explicitly account for the effects of binary interactions between stars. The resulting populations are typically bluer than older stellar pop synth models leading to younger inferred ages for observed populations.

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# The Impact of Binary Fraction Uncertainties on Galaxy Spectra and Colours

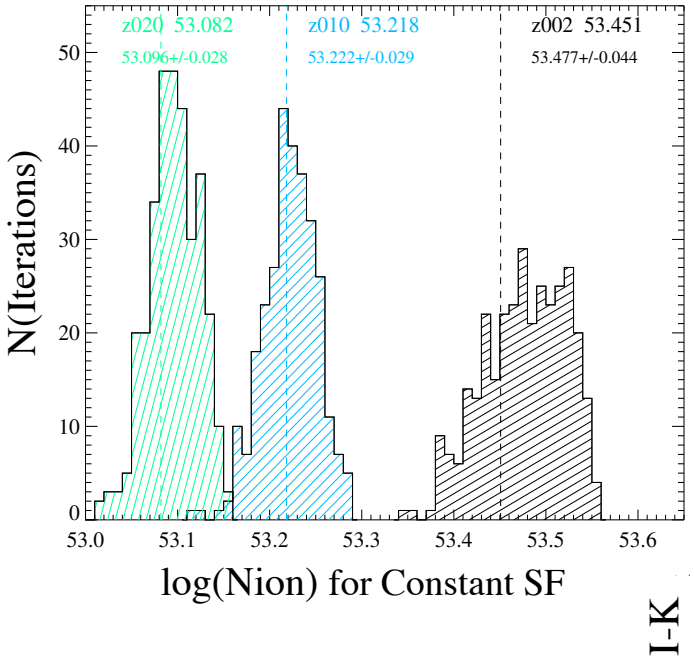


Galaxy colours and spectral features (such as emission lines) are significantly affected by including the effects of binaries, particularly at low metallicity or ages < 1 Gyr. But how well do we understand the underlying binary fraction, periods and mass ratio distribution in stellar populations?

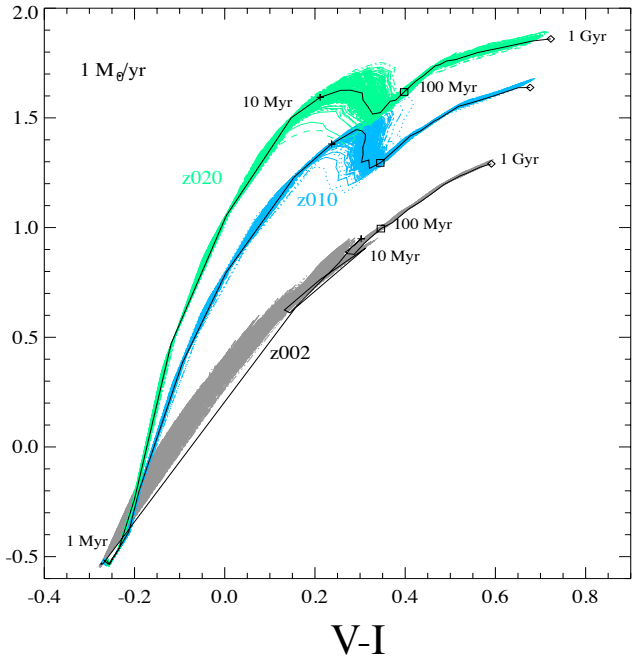
We have explored the impact of uncertainty in binary fraction parameters on the stellar population. Running thousands of models, each with slightly different binary parameters, shows that some properties like the ionizing photon production rate are well constrained, while others, such as the strength of high ionization lines or the inferred age of a population from SED fitting, can be more severely affected.

Fitting with binary populations measurably changes inferred galaxy parameters.

There is no clear, unambiguous indicator of binary fraction in the composite light of unresolved stellar populations.




Left: The uncertainties (arising from binary parameters) on the ionizing photon production rate of a star forming population with a constant rate of 1 $M_{\odot}$ $yr^{-1}$ at 0.1, 0.5 and 1.0 Solar Metallicity




Right: The impact of binary parameter uncertainty on the colours of the integrated stellar light – at certain ages, and particularly at 10-100 Myr, binary parameter choices introduces Δmag > 0.1 uncertainty.

https://ui.adsabs.harvard.edu/abs/2020MNRAS.495.4605S (E R Stanway et al, 2020a, arXiv:2004.11913)

# Will LSST SN surveys shed light on the binary fraction of stars?



LSST will provide unprecedented statistics on supernova rates – but will these provide information on the binary fraction of their stellar progenitors?

BPASS populations include detailed stellar structure models which allow us to explore transient natures and rates across cosmic time.

We have explored the impact of assumed binary fraction distribution on the ratio of thermonuclear to hydrogen-rich and stripped-envelope supernovae. Given 1% precision on the evolution of SN rate ratios as a function of redshift, the stellar binary fraction can be determined to high precision. LSST (according to current estimates) should provide this out to z~1!

But questions remain:

- Will LSST accurately type supernova events from lightcurves alone?
- How well will the volumetric completeness be determined?
- How well do we understand the star formation history and metallicity histories of the Universe?

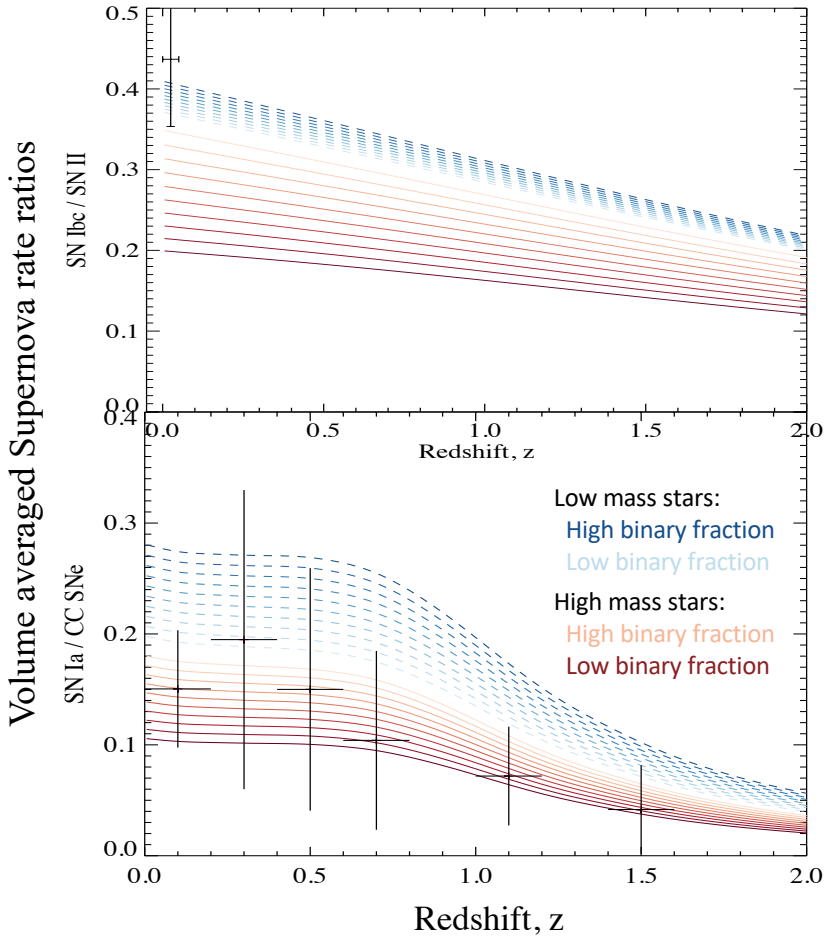



Figure: The effect of binary fraction either in low mass stars (blue) or high mass stars (red) on supernova type ratio. Over-plotted points show current constraints on these ratios

https://ui.adsabs.harvard.edu/abs/2020MNRAS.497.2201S
(E R Stanway et al, 2020b, arXiv:2007.07263)

Bonus Extra: for the Hoki package for analysing BPASS results in Python see https://heloises.github.io/hoki/index.html