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Deep Extragalactic VIsible Legacy Survey (DEVILS): SED Fitting in the D10-COSMOS Field and the Evolution of the Stellar Mass Function and SFR-$M_\star$ relation

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ABSTRACT

We present catalogues of stellar masses, star formation rates, and ancillary stellar population parameters for galaxies spanning $0 < z < 9$ from the Deep Extragalactic VIsible Legacy Survey (DEVILS). DEVILS is a deep spectroscopic redshift survey with very high completeness, covering several premier deep fields including COSMOS (D10). Our stellar mass and star formation rate estimates are self-consistently derived using the spectral energy distribution (SED) modelling code ProSpect, using well-motivated parameterisations for dust attenuation, star formation histories, and metallicity evolution. We show how these improvements, and especially our physically motivated assumptions about metallicity evolution, have an appreciable systematic effect on the inferred stellar masses, at the level of ~0.2 dex. To illustrate the scientific value of these data, we map the evolving galaxy stellar mass function (SMF) for $0 < z < 5$ and the SFR-$M_\star$ relation for $0 < z < 9$. In agreement with past studies, we find that most of the evolution in the SMF is driven by the characteristic density parameter, with little evolution in the characteristic mass and low-mass slopes. Where the SFR-$M_\star$ relation is indistinguishable from a power-law at $z > 2.6$, we see evidence of a bend in the relation at low redshifts ($z < 0.45$). This suggests evolution in both the normalisation *and shape* of the SFR-$M_\star$ relation since cosmic noon. It is significant that we only clearly see this bend when combining our new DEVILS measurements with consistently derived values for lower redshift galaxies from the Galaxy And Mass Assembly (GAMA) survey: this shows the power of having consistent treatment for galaxies at all redshifts.

The variety in FUV-FIR SED: IMF, Dust correction, SFH, Metallicity, binary……

This work: ProSpect + **DEVILS** catalog → stellar mass, dust mass and SFRs

DEVILS is an on-going optical spectroscopic redshift survey (3,394 in COSMOS)

A new photometric catalogue for DEVILS is derived by using photometry code: ProFound (Robotham et al. 2018).

About Redshift: This results in 494,084 galaxies of which 24,099 have spec-z, 7,307 have grism-z, and the remaining: phot-z.

Redshift Source	Type
DEVILS	Spec
zCOSMOS	Spec
hCOSMOS	Spec
LEGA-C	Spec
VVDS	Spec
VUDS	Spec
FMOS	Spec
MOSDEF	Spec
C3R2	Spec
DEIMOS	Spec
LRIS	Spec
ComparatOII	Spec
VIS3COS	Spec
3D-HST	Grism
PRIMUS	Grism
PAU	Photo
COSMOS2015	Photo
MIGHTEE	Photo

SED Modelling: Free parameter (advantage of ProSpect)

BC03 stellar libraries + Chabrier (2003) IMF

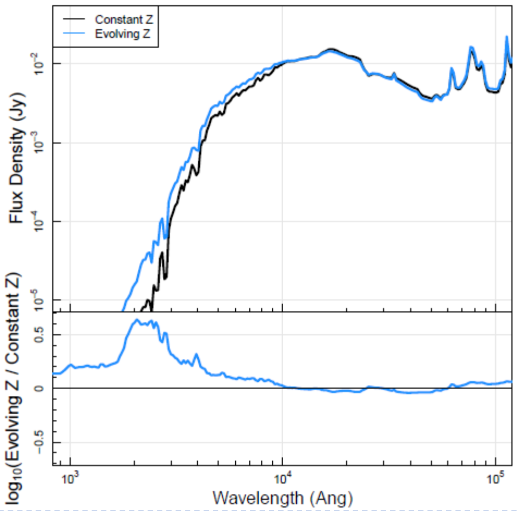
Parameter	Units	Type	Range	Prior
mSFR	$M_\odot yr^{-1}$	Log	[-3,4]	
mpeak	Gyr	Linear	[-2, 13.38]	
mperiod	Gyr	Log	$[\log_{10}(0.3), 2]$	$100\,\mathrm{erf}(\mathrm{mperiod}+2) - 100$
mskew	-	Linear	[-0.5,1]	
Zfinal		Log	[-4, -1.3]	
τ_{birth}		Log	[-2.5, 1.5]	$\exp\left(-\frac{1}{2}\left(\frac{\tau_{birth}-0.2}{0.5}\right)^2\right)$
τ_{screen}		Log	[-5, 1]	$-20\,\mathrm{erf}(\tau_{screen}-2)$
α_{birth}		Linear	[0,4]	$\exp\left(-\frac{1}{2}\left(\frac{\alpha_{birth}+2}{1}\right)^2\right)$
α_{screen}		Linear	[0,4]	$\exp\left(-\frac{1}{2}\left(\frac{\alpha_{screen}+2}{1}\right)^2\right)$

Dust: Charlot & Fall (2000) model + Dale et al. (2014) templates

SFH: Robotham et al. (2020)

- mSFR - the peak SFR of the SFH,
- mpeak - the age of the SFH peak,
- mperiod - the width of the Normal distribution,
- mskew - the skewness of the Normal distribution.

A linearly evolving metallicity:

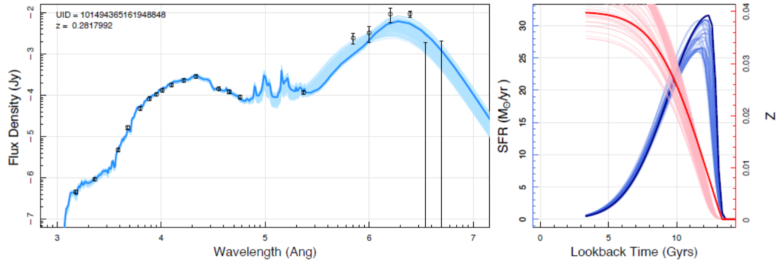


This is similar to the closed-box model of metallicity growth, but the linear model allows for a reasonable amount of inflow

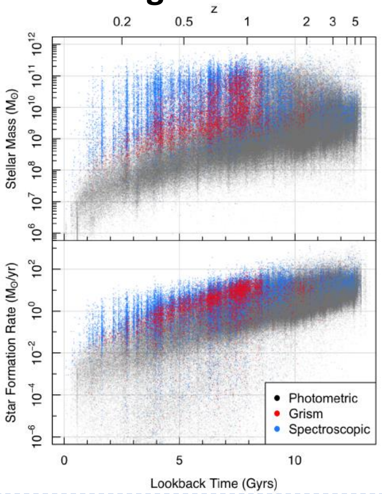
SED sample:

Catalog: No NB data + Exclude PAH bands

Right panel: Red line: Metallicity Blue line: SFR



SED fitting result:



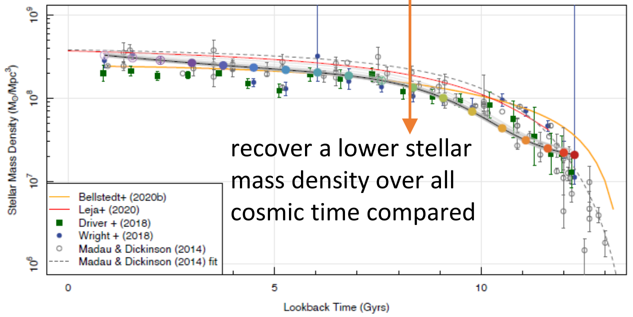
ProSpect-derived stellar mass are higher than COSMOS2015 by 0.21 dex, SFR are lower by 0.05 dex.

Stellar mass function (18 redshift bins, double Schechter)

$$\phi(\mathcal{M}) = \ln(10)e^{-\mu}\left(\phi_1^*\mu^{\alpha_1+1} + \phi_2^*\mu^{\alpha_2+1}\right) \quad \alpha_1 \sim -0.5,\ \alpha_2 \sim -1.5$$

Characteristic mass & α : no evolution over the redshift range

Normalization: redshift-dependent evolution & **lower** fitted values

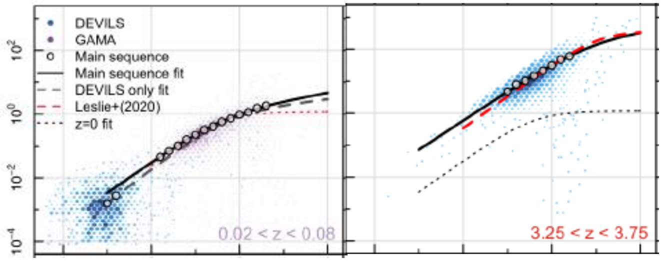


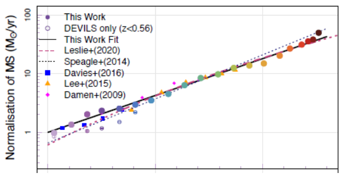
recover a lower stellar mass density over all cosmic time compared

SFMS: (20 redshift bins)

Turnover at $\sim 10^{10}\ M_\odot$, $\alpha \sim 1, \beta \sim 0.2$

$$\log_{10}(\mathrm{SFR}) = \mathcal{S}_0 - \log_{10}\left[\left(\frac{10^{\mathcal{M}}}{10^{\mathcal{M}_0}}\right)^{-\alpha} + \left(\frac{10^{\mathcal{M}}}{10^{\mathcal{M}_0}}\right)^{-\beta}\right],$$





The shape of the main sequence evolves with redshift

Bend: massive galaxies start to undergo quenching at $z < 1.5$.