Measuring star formation in galaxies and its evolution

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Evolution of Star Formation

Madau et al., 1996 MNRAS 283, 1368
Evolution of Star Formation


\[ \rho_s (M_\odot \, \text{yr}^{-1} \, \text{Mpc}^{-3}) \]

\[ 0.01 \text{ to } 0.1 \]

\[ 0 \text{ to } 0.2 \]

\[ 0.4 \text{ to } 0.6 \]

\[ 0.8 \]

\[ \log(1+z) \]
Evolution of Star Formation

Evolution of Star Formation


\[ \rho_*(M_\odot \text{ yr}^{-1} \text{ Mpc}^{-3}) \]

\[ \log(1+z) \]

[Graph showing the evolution of star formation rate with redshift.]
Evolution of Star Formation

Evolution of Star Formation

Star formation tracers

- Pretty much everything!
- Some handle on massive stellar population, either direct or indirect.
- Photometric: UV, u-band, mid-IR, far-IR, radio, X-ray.
- Spectroscopic: Hydrogen recombination lines, Balmer $\text{H}\alpha$ especially, but also $\text{H}\beta$, Paschen lines in NIR, $\text{Ly}\alpha$ for high-$z$, and forbidden lines, primarily $\text{[OII]}$, but also $\text{[OIII]}$.
- Other: GRB rate, broad-band (optical) luminosity density plus SFH models.
Star formation tracers: SDSS

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GAMA

GAMA Key Science

★ A measurement of the dark matter halo mass function of groups and clusters using group velocity dispersion measurements.

★ A comprehensive determination of the galaxy stellar mass function to Magellanic Cloud masses to constrain baryonic feedback processes.

★ A direct measurement of the recent galaxy merger rates as a function of mass, mass ratio, local environment and galaxy type.
MW SFR: FUV vs Hα

Obscuration curves

FUV vs Hα

Luminosity-dependent obscuration

\[ \log(L_{\text{H}\alpha}) \]

SED fitting using MAGPHYS from Da Cunha et al. (arXiv:1111.3961)
http://www.iap.fr/magphys
Driver et al, (in prep)
The GAMA Hα Luminosity Function

Gunawardhana et al., 2012, MNRAS (submitted)
The GAMA H\(\alpha\) Luminosity Function

Gunawardhana et al., 2012, MNRAS (submitted)
The GAMA H\textalpha Luminosity Function

Gunawardhana et al., 2012, MNRAS (submitted)
The GAMA Hα Luminosity Function

Gunawardhana et al., 2012, MNRAS (submitted)
Cosmic SFR density

Gunawardhana et al., 2012, MNRAS (submitted)
Bivariate $\text{H}\alpha - M_r$ luminosity distribution

Gunawardhana et al., 2012, MNRAS (submitted)
Bivariate Hα-M_r luminosity distribution

Gunawardhana et al., 2012, MNRAS (submitted)
Evolution of the stellar initial mass function?

Initial mass function variations?

Initial mass function variations?

Initial mass function variations?

Conclusions

- SED modelling is likely to be the most robust approach to accurately estimating global SFRs for galaxies, but: (1) need to have a good stellar evolution template library; and (2) need to worry about obscuration and IMFs.

- Sensitive radio (SKA!) and FIR observations may ultimately turn out to be the most reliable, simple approach, but: (1) needs careful calibration; and (2) need to worry about AGN “contamination”.

- Star formation in galaxies follows a Saunders (or two-power law) distribution, not a Schechter function.

- The Hα luminosity function from GAMA and SDSS confirms this for the first time, making Hα finally consistent with other wavelength estimators of SFR.
http://www.gama-survey.org/

The second GAMA public data release is scheduled for October 2012. Data release will include not only flux-calibrated spectra and redshifts, but derived products such as improved photometry, stellar masses, emission line measures and SFRs, group catalogue and membership, and more.
GAMA survey area
Redshift distribution

MW SFR: H\(\alpha\) vs [OII]

MW SFR in GAMA

GAMA Additional Science

- Galaxy evolution: SFR dependence on environment, merger rate, galaxy type/morphology, mass, etc.
- Obscuration, radiation balance between UV/IR, dependence on other galaxy properties, evolution.
- IMF variations?
- Metallicity evolution, dependence on galaxy properties, environment, etc.
- Cluster/group properties, evolution, role in galaxy evolution.
- Relationship between single-fibre galaxy properties and resolved spectroscopic properties from integral-field spectroscopic measurements.
- Stellar/gas inter-relationships (GAMA+DINGO): galaxy fueling/stripping/feedback, etc. Stellar mass function, HI mass function, baryonic mass function.
- AGN evolution, feedback mechanisms, (radio continuum from EMU).
- And much, much more!