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The neutral gas content of galaxies over time

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An outstanding problem in extragalactic astrophysics:



If neutral gas is the fuel for star formation, why the star formation history of the Universe looks so much different than the HI history of it?

Optical colours of a cluster



Major progress in SAMs regarding gas (HI, H2 and CO) predictions (Lagos et al. 2011a,b, 2012a,b, 2014; Cook et al. 2010; Fu et al. 2010, 2011; Popping et al. 2013a,b)



The galaxy formation semi-analytic technique

(3) Semi-analytic technique

(1) Dark matter N-body simulation



Development: The Pressure Star Formation Law

Blitz & Rosolowsky (2006); Wong et al. (2002); Leroy et al. (2008); Bigiel et al. (2008,2010); Schruba et al. (2011); Genzel et al. (2013)









Lagos et al. (2011a,b) Lagos et al. (2014a)

(1) The evolution of total neutral gas: outflow vs. inflow (quasi-equilibrium)
(2) The size evolution of galaxies: gas density





Which galaxies dominate the HI and H2 content of the Universe?

Lagos et al. (2014a)





Evolution of the H2 mass function

Lagos et al. (2012a): PDR radiative transfer model combined with GALFORM to predict CO emission lines (from 1-0 to 10-9).





Conclusions

(1) Major progress: *SAM has shown to be a powerful tool* to study the connection SF/HI/H2



(2) GALFORM has been tested extensively: SFR, HI, H2

scaling relations and evolution

(3) Models predict the *different evolution of SFR and HI density* Their differences are due to balance inflow/outflow and size evolution of galaxies.



(4) Strong evolution of the H2 mass function and density.



Lagos et al. (2011a,b); Geach et al. (2011); Lagos et al. (2012a,b); Kim et al. (2013b, 2014); Swinbank et al. (2013); Lagos et al. (2013a); Lagos et al. (2014a,b)