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On the origin of the color Tully-Fisher and color-magnitude relations of disk galaxies

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• The increment of the slope of the T-F relation (TFR) with the passband wavelength has been called the **color TFR**. For example, from the observed $K-$ and $B-$band TFRs one obtains that $L_K/L_B \propto V_m^{0.6}$ (Pierce & Tully1999, ApJ, 387,47). Since L_K traces the stellar disk mass M_s, then $M_s/L_B \propto V_m^{0.6}$. The empirical fact that more luminous galaxies tend to be redder have been called the **color-magnitude relation**: $(B-H) \propto \gamma \log L_B$, $\gamma \approx 0.4-1.2$.

• **Why the mass-to-luminosity ratio and the color index of disk galaxies do depend on V_m (or luminosity)?** At least there are three alternatives: the star formation (SF) efficiency, the gas infall efficiency and/or the internal face-on dust extinction depend on the galaxy mass. We explore the last alternative since self-consistent models of disk galaxy evolution within the hierarchical formation scenario show that the M_s/L_B ratio and $B-H$ do not significantly depend on mass or luminosity (Avila-Reese & Firmani 2000, RevMexA&A, v. 36, in press; Avila-Reese et al., this volume).

• Observations indeed show that dust and metallicity increase with L_B. In a more quantitative fashion, Wang & Heckman (1996: ApJ, 457, 645, WH) have established that the UV(young massive stars)-to-FIR (the same young stars **+dust absorption**) ratio decreases rapidly with L_B $\Rightarrow$ **the dust opacity increases with L_B:** $\tau_B = \tau_{B,o}(L_B/L_{B,o})^{\beta}$ (eq. 1), with $L_{B,o} = 1.3 \times 10^{10} L_{B\odot}$, $\tau_{B,o} = 0.8 \pm 0.3$, and $\beta = 0.5 \pm 0.2$ (WH).

• Applying the uniform slab model, and using eq. (1) with the central values for the constants, a good approximation for the extinction in the range of $10^8 - 10^{11} L_{B\odot}$ is: $A_B \approx 0.38 + 0.42 \log L_{B,10} + 0.14 (\log L_{B,10})^2$ (eq. 2). Assuming that in the H band dust absorption is negligible, this result shows that $(B-H)$ will redden due to dust extinction roughly as $\propto 0.42 \log L_B$, which reasonable agrees with that is observed. On the other hand, in the understanding that the origin of the TFR in the different bands is common, the fact that $L_K/L_B \propto V_m^{0.6}$ is easily accounted for the $B-$band extinction given by eq. (2). In the hierarchical scenario of galaxy formation indeed the TFR for any band is a common imprint of the mass-velocity relation of the CDM halos.

• In conclusion, *the luminosity-dependent dust extinction reported by WH easily explains the color TF and color-magnitude relations of disk galaxies;* there is not necessity to evoke mass dependent SF and gas infall efficiencies. The extinction could depend on mass because the efficiency of metal ejection out of the disk might be larger for smaller galaxies and/or because more massive galaxies have higher surface densities than the smaller ones.

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