The dust effects on galaxy scaling relations

Bogdan A. Pastrav (Institute of Space Science, Bucharest-Romania)
(bapastrav@spacescience.ro)

Accurate galaxy scaling relations are essential for a successful model of galaxy formation and evolution as they provide direct information about the physical mechanisms of galaxy assembly over cosmic time. We present here a detailed analysis of a sample of nearby spiral galaxies taken from the KINGFISH survey. The photometric parameters of the morphological components are obtained from bulge-disk decompositions using GALFIT data analysis algorithm, with surface photometry of the sample done beforehand. The method and the library of numerical results previously obtained in Pastrav et al. (2013a,b) are used to correct the measured photometric parameters for inclination, dust and decomposition effects in order to derive their intrinsic (face-on, dust free) values. Galaxy scaling relations are then presented with and without corrections for these effects, at various wavelengths and derived dust opacities. While our sample is rather small, it is sufficient to emphasize the influence of galaxy environment (dust, in this case) when deriving scaling relations.

Motivation
Dust biases all the galaxy structural & photometric parameters (and not only) involved in scaling relations, with other effects having a contribution - inclination and decomposition effects (Pastrav et al. 2013a,b). Not having accurate intrinsic scaling relations can have implications for models of galaxy evolution.

Sample
14 unbarred spiral galaxies from the KINGFISH survey (Kennicutt et al. 2011) see Table 1

Method
The following steps were followed:
- structural analysis of the sample performing bulge-disk decompositions using parametric functions (exponential+Sersic) available in GALFIT 3.02 (Peng et al. 2010) data analysis algorithm and star-masking routines developed by Richard Tuffs (MPK);
- surface photometry to derive total integrated fluxes using curve-of-growth method;
- derive the central face-on dust optical depth in B band using the correlation between B band face-on dust opacity and stellar mass surface density discovered by Grootes et al. (2013),

\[
\tau_B = \log(g_T) - 1.12 \pm 0.11 - \log \left( \frac{M_d}{M_{\star}} \right) - 8.6 \pm 0.3 \]

with stellar masses taken from Grossi et al. (2015) (see Table 1);
- derive the face-on dust mass, dust-to-star mass ratio, intrinsic face-on central surface brightness and stellar mass surface density using eq. (A5) from Grootes et al. (2013), dust-corrected values for these effects (black) and with corrections for these effects included (red);
- inclination, dust and decomposition effects (Pastrav et al. 2013a,b). Not having accurate intrinsic scaling relations can have implications for models of galaxy evolution.

References

The following steps were followed:

- structural analysis of the sample performing bulge-disk decompositions using parametric functions (exponential+Sersic) available in GALFIT 3.02 (Peng et al. 2010) data analysis algorithm and star-masking routines developed by Richard Tuffs (MPK);
- surface photometry to derive total integrated fluxes using curve-of-growth method;
- derive the central face-on dust optical depth in B band using the correlation between B band face-on dust opacity and stellar mass surface density discovered by Grootes et al. (2013),

\[
\tau_B = \log(g_T) - 1.12 \pm 0.11 - \log \left( \frac{M_d}{M_{\star}} \right) - 8.6 \pm 0.3 \]

with stellar masses taken from Grossi et al. (2015) (see Table 1);
- derive the face-on dust mass, dust-to-star mass ratio, intrinsic face-on central surface brightness and stellar mass surface density using eq. (A5) from Grootes et al. (2013), dust-corrected values for these effects (black) and with corrections for these effects included (red);
- inclination, dust and decomposition effects (Pastrav et al. 2013a,b). Not having accurate intrinsic scaling relations can have implications for models of galaxy evolution.

Results
Some of the results obtained are presented in Table 1, below.

Conclusions
- inclination, dust and decomposition affects all the parameters involved in disk scaling relations, changing the slope of these relations to smaller values, with dust effects having the most significant contribution;
- inclination of these effects changes the dust masses derived for the galaxies in the sample, with a decrease of up to 0.5 dex in the total mass;
- as a consequence, dust to star ratio is also decreased when considering the above effects, which may have implications for models of dust production and evolution;
- the average central face-on dust opacity derived in this study (\(\tau_B = 3.59 \pm 0.38\)) is consistent with the value of \(3.8 \pm 0.7\) found by Driver et al. (2007); the same for the average dust to star ratio value - \((1.36 \pm 0.02)x10^{-3}\), consistent with the value of \(0.95x10^{-3}\) found by Skibba et al. (2011).

Conclusions
- inclination, dust and decomposition affects all the parameters involved in disk scaling relations, changing the slope of these relations to smaller values, with dust effects having the most significant contribution;
- inclination of these effects changes the dust masses derived for the galaxies in the sample, with a decrease of up to 0.5 dex in the total mass;
- as a consequence, dust to star ratio is also decreased when considering the above effects, which may have implications for models of dust production and evolution;
- the average central face-on dust opacity derived in this study (\(\tau_B = 3.59 \pm 0.38\)) is consistent with the value of \(3.8 \pm 0.7\) found by Driver et al. (2007); the same for the average dust to star ratio value - \((1.36 \pm 0.02)x10^{-3}\), consistent with the value of \(0.95x10^{-3}\) found by Skibba et al. (2011).

References

Photo by Robert Gendler, NASA/ESA, Subaru and DSS