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# The Stellar Mass Fundamental Plane: The virial relation and a very thin plane for slow-rotators

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**ABSTRACT**

Early-type galaxies – slow and fast rotating ellipticals (E-SRs and E-FRs) and S0s/lenticulars – define a Fundamental Plane (FP) in the space of half-light radius $R_e$, enclosed surface brightness $I_e$ and velocity dispersion $\sigma_e$. Since $I_e$ and $\sigma_e$ are distance-independent measurements, the thickness of the FP is often expressed in terms of the accuracy with which $I_e$ and $\sigma_e$ can be used to estimate sizes $R_e$. We show that: 1) The thickness of the FP depends strongly on morphology. If the sample only includes E-SRs, then the observed scatter in $R_e$ is $\sim 16\%$, of which only $\sim 9\%$ is intrinsic. Removing galaxies with $M_* < 10^{11} M_\odot$ further reduces the observed scatter to $\sim 13\%$ ($\sim 4\%$ intrinsic). The observed scatter increases to the $\sim 25\%$ usually quoted in the literature if E-FRs and S0s are added. If the FP is defined using the eigenvectors of the covariance matrix of the observables, then the E-SRs again define an exceptionally thin FP, with intrinsic scatter of only 5% orthogonal to the plane. 2) The structure within the FP is most easily understood as arising from the fact that $I_e$ and $\sigma_e$ are

# Фундаментальная плоскость сфероидальных галактик

$$R_e \propto \sigma_e^{\alpha} I_e^{\beta},$$

$$M \propto k_n \frac{R_e \sigma_e^2}{G},$$

Следствие теоремы вириала?

Есть наклон!

fact that $L \propto I_e R_e^2$ and rearranging makes this

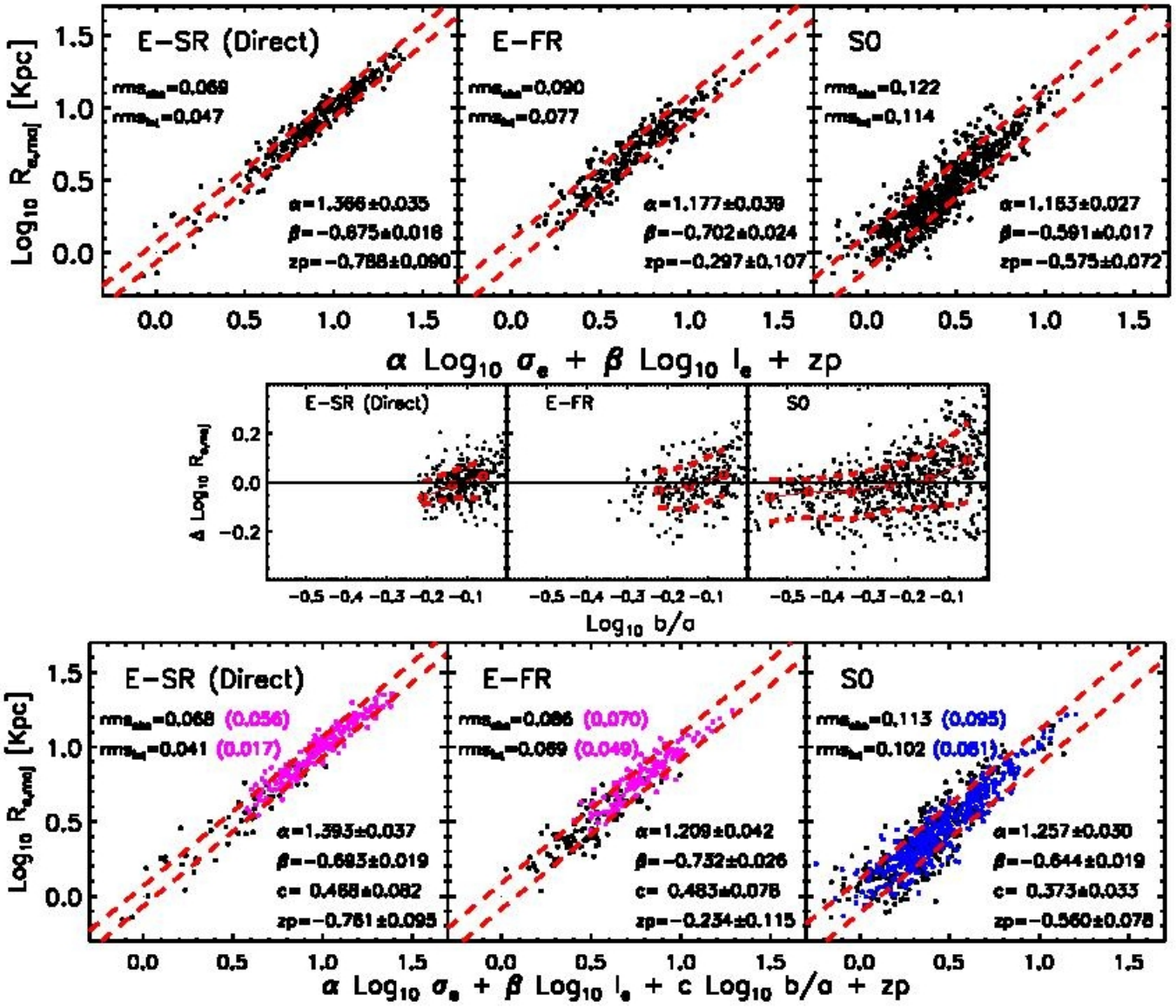
$$R_e \propto k_n \frac{\sigma_e^2}{I_e} \left(\frac{M_*}{L}\right)^{-1} \left(\frac{M_*}{M}\right), \qquad (3)$$

[1] Hyde & Bernardi (2009) used SDSS survey photometry because Sérsic photometry for SDSS was not yet available and because dynamical mass estimates from SAURON (Cappellari et al. 2006) suggested that galaxies were homologous, so this was not necessary. However, recent work suggests that such dynamical mass estimates should be treated with caution (Bernardi et al. 2018b, 2019).

# Выборка

- MaNGA
- Но и по апертурной спектроскопии SDSS получается то же самое

# Вот этот наклон – когда меряем яркость!



# Вариации Fitting'a

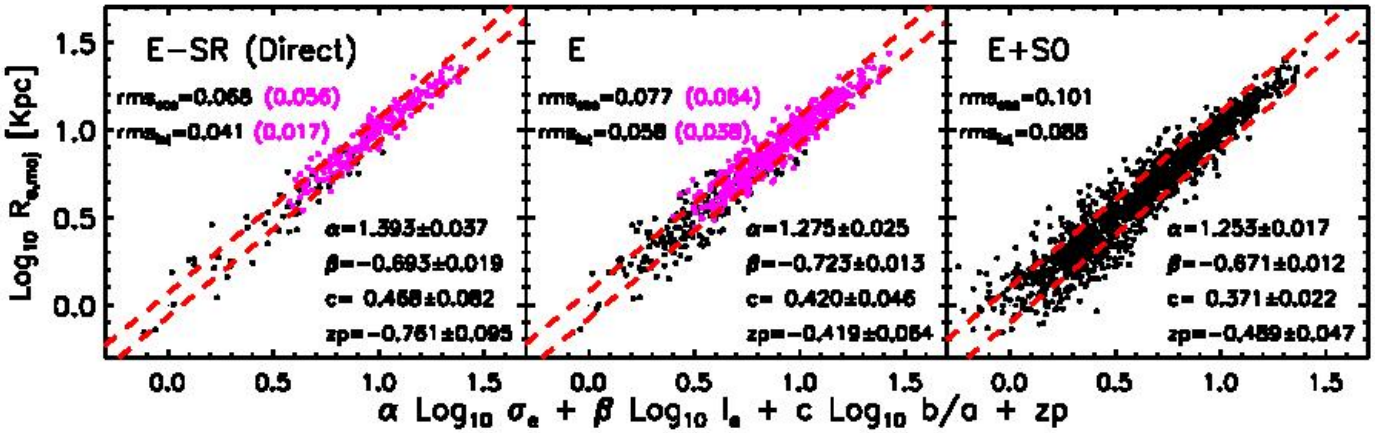



**Figure 2.** 'Cumulative' version of $FP_L$ shown in bottom panels of Figure 1: middle panels show Es = E-SR + E-FRs, and right hand panels show E+S0s.

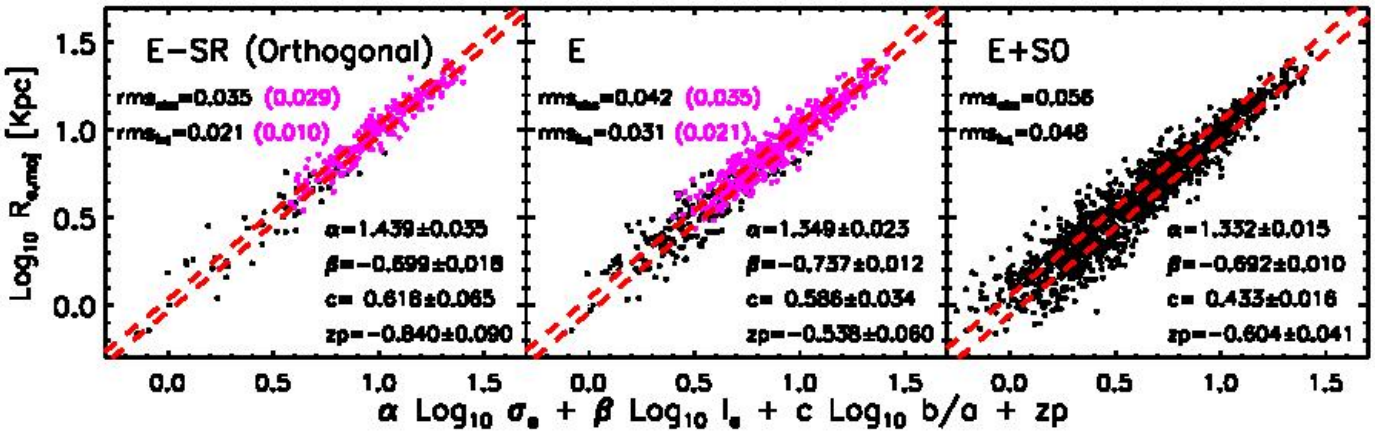


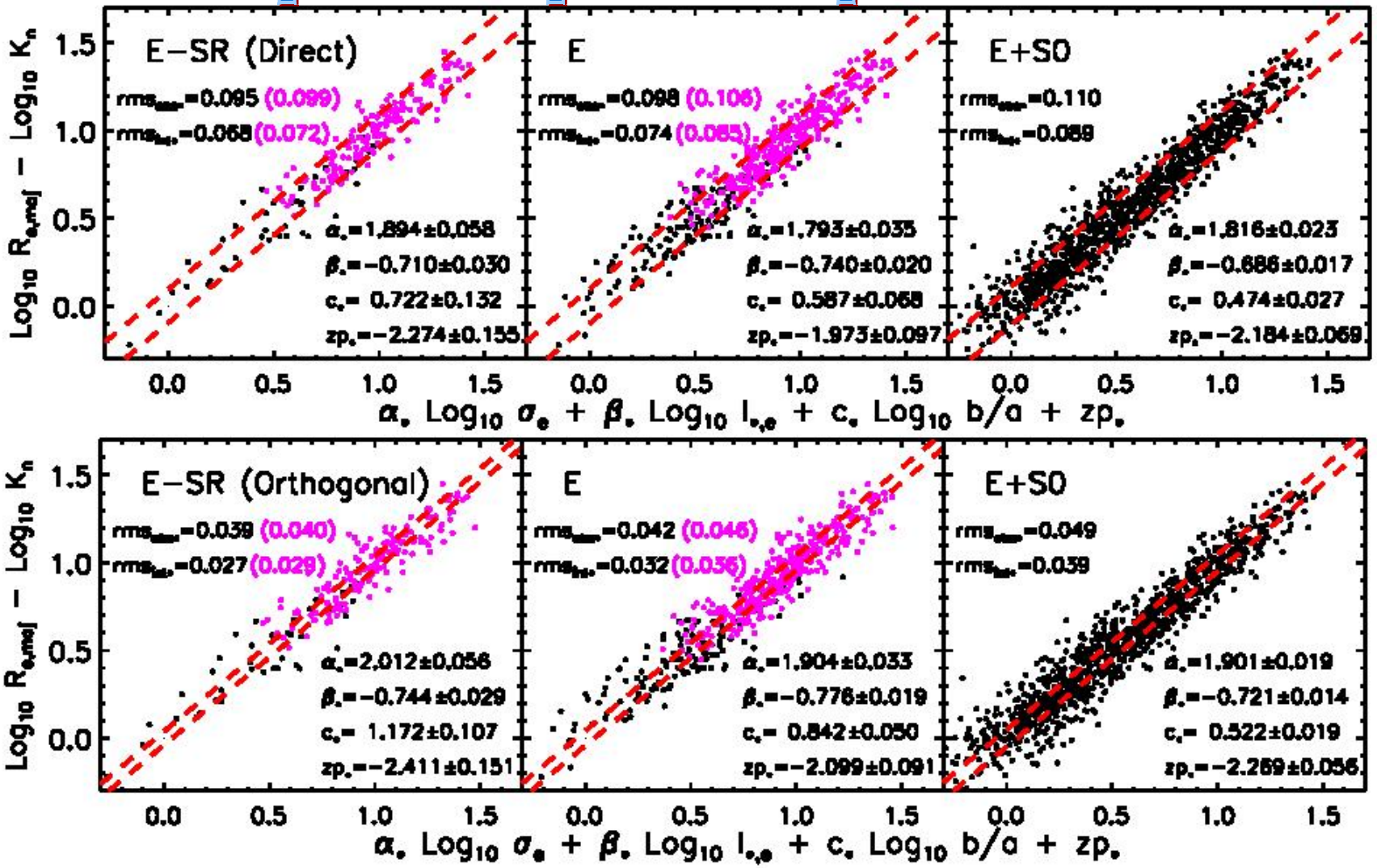

**Figure 3.** Same as Figure 2, but now showing the orthogonal fits.

# Причины наклона фундаментальной плоскости

- Разница в свойствах звездного населения ( отношение массы к светимости)?
- Разница в радиальном распределении плотности (не-гомология)?
- Разница в доле темной материи внутри эффективного радиуса?

При переходе от яркости к массе зависимость от кинематики становится вириальной

**Убираем первые 2 причины!**



# Что остается?

- Эффективность звездообразования и/или доля темной материи коррелирует с поверхностной плотностью!