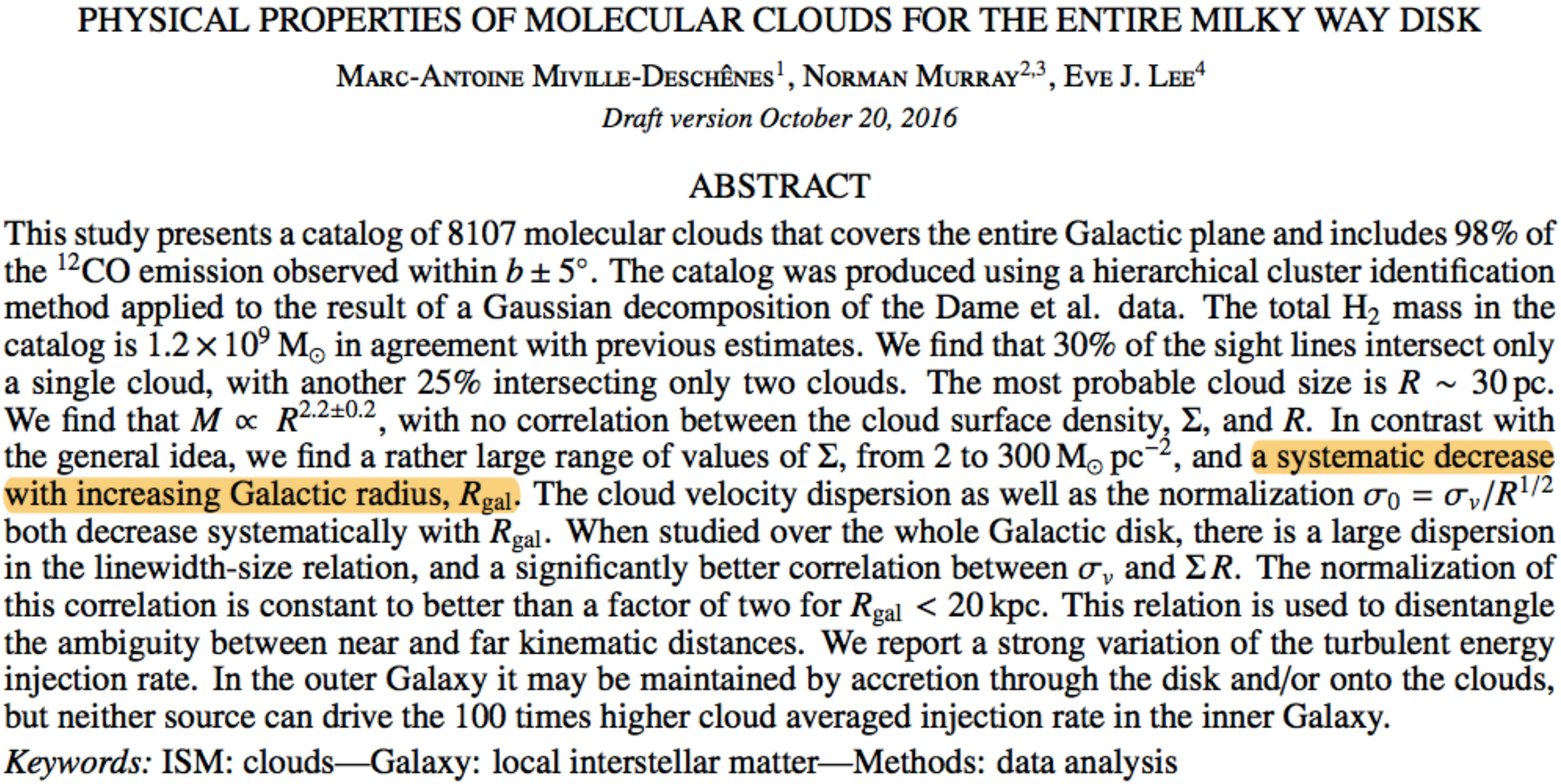
arXiv:1610.05918



PHYSICAL PROPERTIES OF MOLECULAR CLOUDS FOR THE ENTIRE MILKY WAY DISK

MARC-ANTOINE MIVILLE-DESCHÊNES[1], NORMAN MURRAY[2,3], EVE J. LEE[4]

Draft version October 20, 2016

ABSTRACT

This study presents a catalog of 8107 molecular clouds that covers the entire Galactic plane and includes 98% of the ^{12}CO emission observed within $b \pm 5°$. The catalog was produced using a hierarchical cluster identification method applied to the result of a Gaussian decomposition of the Dame et al. data. The total H_2 mass in the catalog is 1.2×10^9 $M_\odot$ in agreement with previous estimates. We find that 30% of the sight lines intersect only a single cloud, with another 25% intersecting only two clouds. The most probable cloud size is $R \sim 30$ pc. We find that $M \propto R^{2.2\pm0.2}$, with no correlation between the cloud surface density, Σ, and R. In contrast with the general idea, we find a rather large range of values of Σ, from 2 to 300 $M_\odot$ pc^{-2}, and a systematic decrease with increasing Galactic radius, $R_{\rm gal}$. The cloud velocity dispersion as well as the normalization $\sigma_0 = \sigma_v/R^{1/2}$ both decrease systematically with $R_{\rm gal}$. When studied over the whole Galactic disk, there is a large dispersion in the linewidth-size relation, and a significantly better correlation between σ_v and ΣR. The normalization of this correlation is constant to better than a factor of two for $R_{\rm gal} < 20$ kpc. This relation is used to disentangle the ambiguity between near and far kinematic distances. We report a strong variation of the turbulent energy injection rate. In the outer Galaxy it may be maintained by accretion through the disk and/or onto the clouds, but neither source can drive the 100 times higher cloud averaged injection rate in the inner Galaxy.

Keywords: ISM: clouds—Galaxy: local interstellar matter—Methods: data analysis

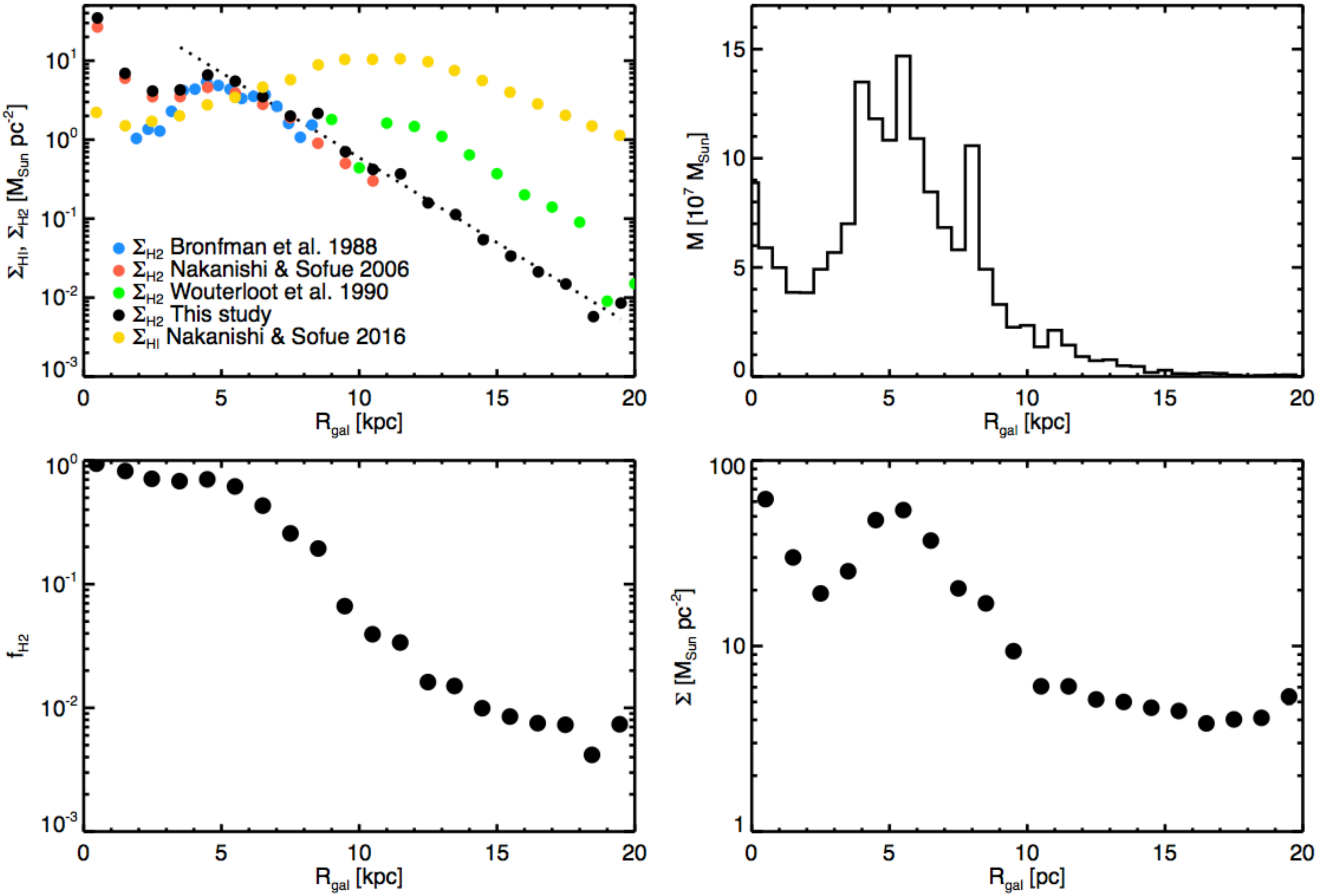


Figure 9. **Top left:** Surface density of H_2 mass as a function of galacto-centric radius (black points). The blue, red and green points correspond respectively to the estimate of Bronfman et al. (1988), Nakanishi & Sofue (2006) and Wouterloot et al. (1990). The dotted line is the exponential fit over the range $4 < R_{gal} < 17$ kpc: $\Sigma = 83 \exp(-R_{gal}/2.0)$. The yellow points correponds to the HI surface density of Nakanishi & Sofue (2016). **Top right:** Total mass of clouds in Galacto-centric rings (thickness 0.5 kpc), as a function of R_{gal}. **Bottom left:** Molecular fraction $f_{H2} = \Sigma_{H2}/(\Sigma_{HI} + \Sigma_{H2})$ built using our estimate of Σ_{H2} and Σ_{HI} from Nakanishi & Sofue (2016). **Bottom right:** Variation of the median cloud mass surface density Σ as a function of Galactocentric radius.

- Because the identification method is able to include emission down to the sensitivity limit, a population of low Σ clouds in the outer Galaxy is revealed. We also report a significant cloud to cloud variation of Σ (from 2 to 300 M pc2) in contrast with the general idea that molecular clouds have a constant mass surface density.
- The inner Galaxy hosts the most massive clouds of the sample: both the average values of *M* and Σ decrease with *R* . On the other hand we note that the median gal cloud size does not vary significantly from the inner to the outer Galaxy.

The typical volume density is *nH2* ⇠ 10 cm3 , well be- low the CO critical density. This suggests that molec- ular clouds are in fact multi-phase objects where dense structures occupy a small fraction of the volume.

- Because the identification method is able to include emission down to the sensitivity limit, a population of low Σ clouds in the outer Galaxy is revealed. We also report a significant cloud to cloud variation of Σ (from 2 to 300 $\mathrm{M_\odot\,pc^{-2}}$) in contrast with the general idea that molecular clouds have a constant mass surface density.

The inner Galaxy hosts the most massive clouds of the sample: both the average values of M and Σ decrease with R_{gal}. On the other hand we note that the median cloud size does not vary significantly from the inner to the outer Galaxy.

- The typical volume density is $n_{\mathrm{H2}} \sim 10\,\mathrm{cm^{-3}}$, well below the CO critical density. This suggests that molecular clouds are in fact multi-phase objects where dense structures occupy a small fraction of the volume.

- The typical volume density is $n_{\mathrm{H2}} \sim 10\,\mathrm{cm}^{-3}$, well below the CO critical density. This suggests that molecular clouds are in fact multi-phase objects where dense structures occupy a small fraction of the volume.

- On average, molecular clouds are on the verge of being in virial equilibrium, with $\alpha_{\mathrm{vir}} \sim 3 - 4$. There is a very large cloud-to-cloud variation of α_{vir}. Only 15% of the clouds are gravitationnaly bound ($\alpha_{\mathrm{vir}} \leq 3$) but they represent 40% of the molecular mass.

  We do not observe a strong variation of α_{vir} with R_{gal}. There is a slight decrease of α_{vir} in the molecular ring and an increase towards the Galactic center.

Astrophys Space Sci (2014) 353:595–602
DOI 10.1007/s10509-014-2084-7

ORIGINAL ARTICLE

Can molecular clouds live long?

A. Zasov · A. Kasparova

Received: 11 July 2014 / Accepted: 26 July 2014 / Published online: 7 August 2014

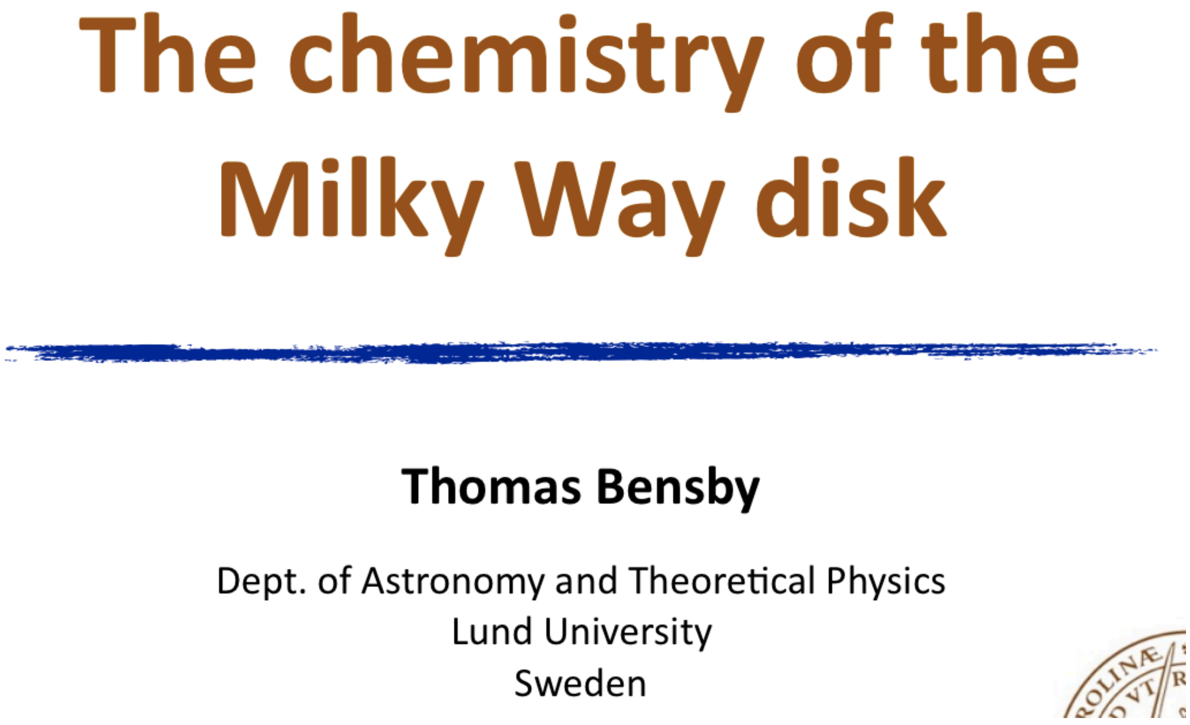
Abstract It is generally accepted that the lifetime of molecular clouds does not exceed 3×10^7 yr due to disruption by stellar feedback. We put together some arguments giving evidence that a substantial fraction of molecular clouds (primarily in the outer regions of a disc) may avoid destruction process for at least 10^8 yr or even longer. A molecular cloud can live long if massive stars are rare or absent. Massive stars capable to destroy a cloud may not form for a long time if a cloud is low massive, or stellar initial mass function is top-light, or if there is a delay of the beginning of active star formation. A long duration of the inactive phase of clouds may be reconciled with the low amount of the observed starless giant molecular clouds if to propose that they were preceded by slowly contraction phase of the magnetized *dark gas*, non-detected in CO-lines.

Keywords Galaxies: ISM · ISM: clouds

and a cloudy forms, which is responsible for star formation. Hence, the conditions of formation and dissolution of molecular clouds determines the character of evolution of starforming galaxy.

Molecular clouds (MCs) may be formed either as the result of collision of gaseous flows (the expanding envelopes, supersonic turbulence, large-scale density waves) or by gravitational (magnetogravitational) instabilities of interstellar medium. In the former case the resulting clouds are non-bound as a whole, hence their lifetime is relatively short. In the latter case the gravitationally bound clouds are formed, including massive giant molecular clouds (GMCs) which are not so easy to disrupt. The relative role of these two ways of formation is the matter of debate. Measurements of cloud masses and their internal velocity dispersions indicate that a significant part of MCs are virialized (gravitationally bound) or close to the virial state (Heyer et al. 2009; Roman-Duval et al. 2010; Colombo et al. 2014). On the other hand, according to Dobbs et al. (2011), many

По докладу на конфер. в Париже по MW (сент 2016)

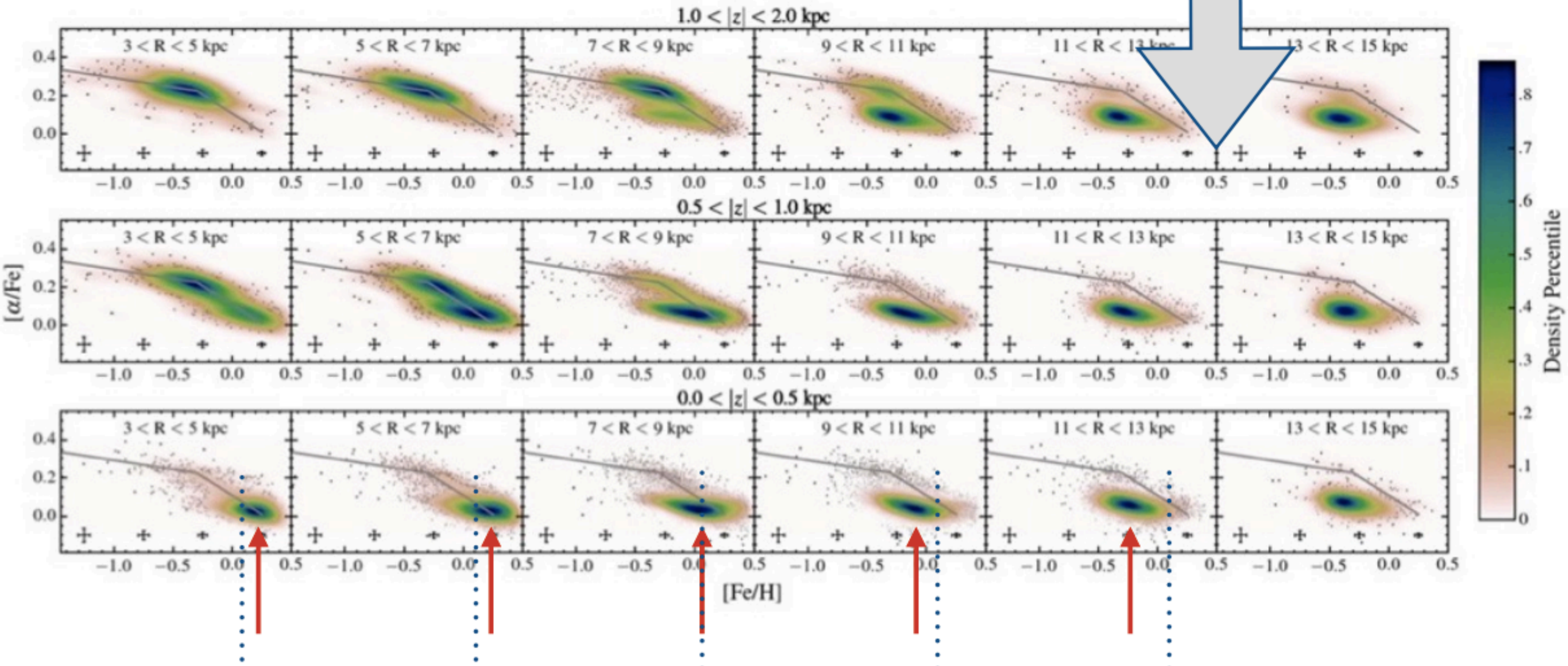


The chemistry of the Milky Way disk

Thomas Bensby

Dept. of Astronomy and Theoretical Physics
Lund University
Sweden

No alpha-enhanced stars!



Abundance gradient in the thin disk

- Hayden et al. (2015), based on red giants from APOGEE DR12

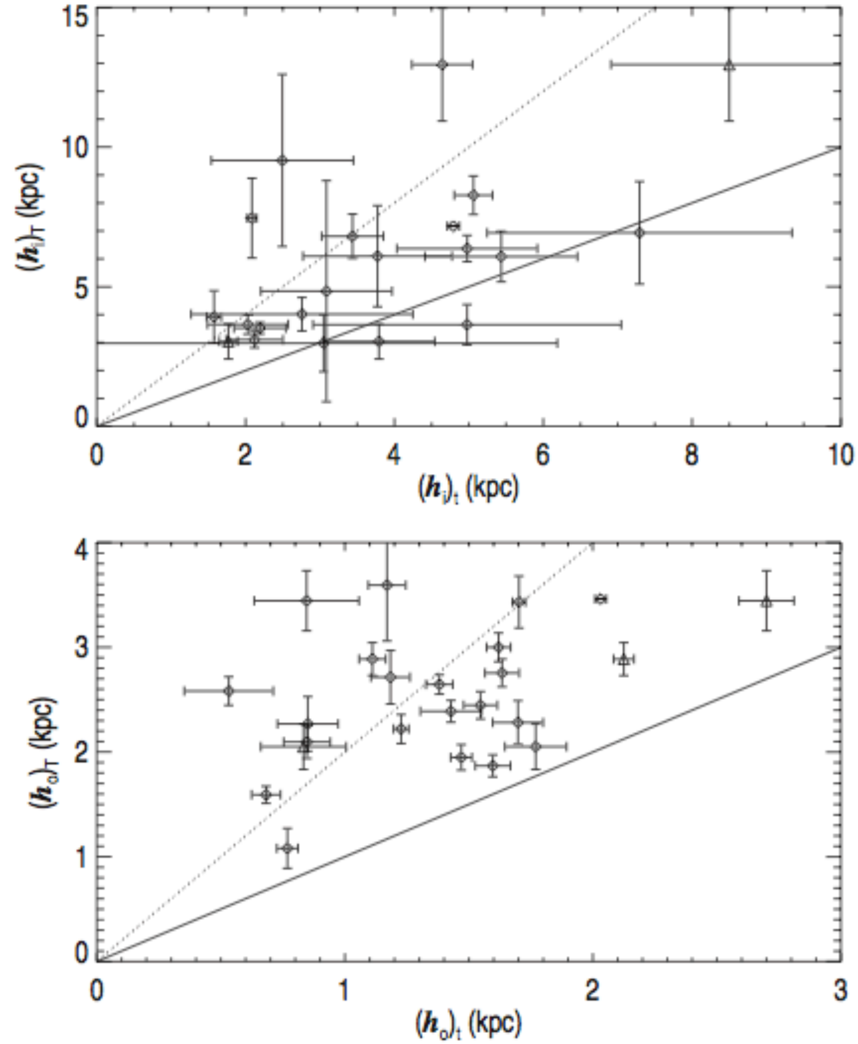
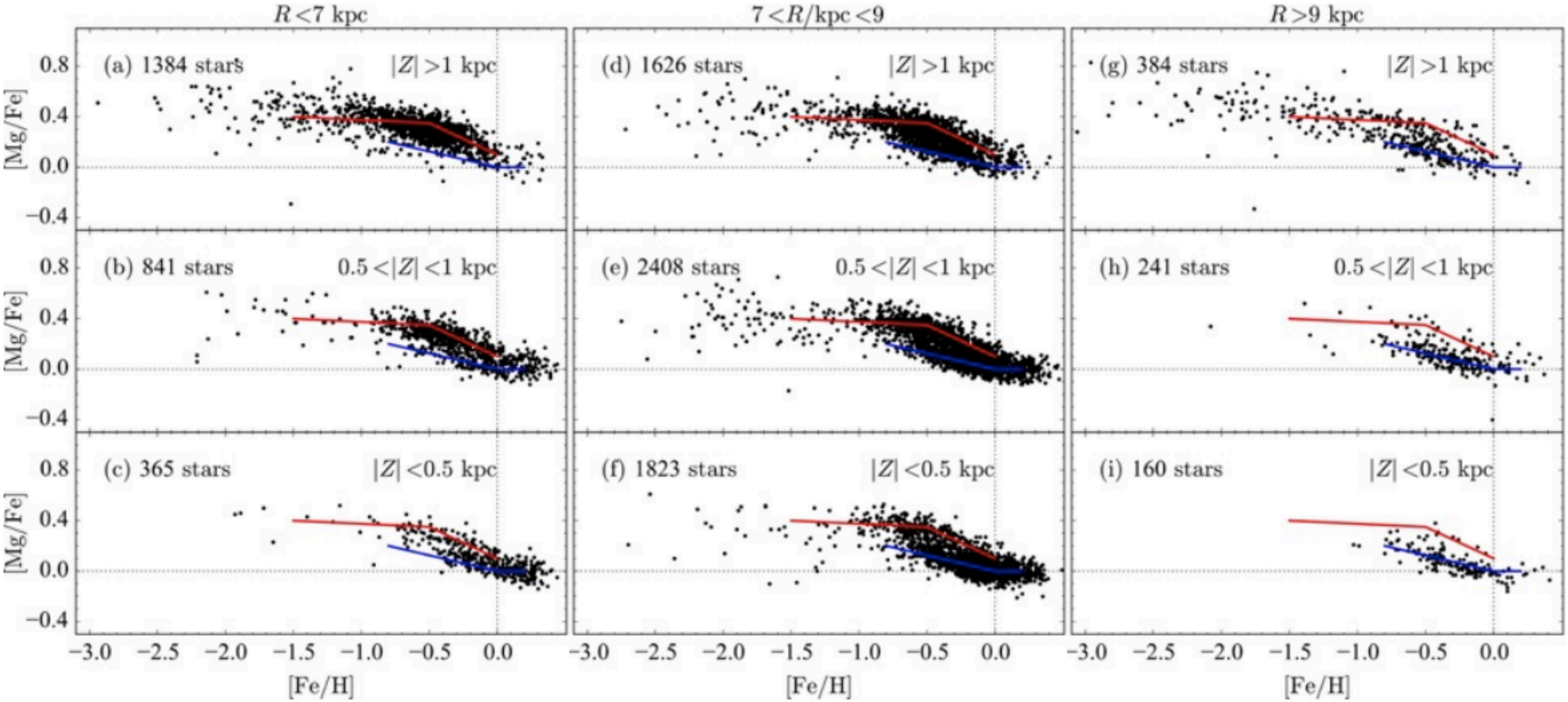


Figure 11. Scale lengths of inner thick disks as a function of their inner thin disks scale lengths (top panel) and scale lengths of outer thick disks as a function of their thin disk scale lengths (bottom panel) for galaxies with both thin and thick disk truncated. Solid lines trace a one-to-one relation between the thin and thick disk scale lengths and the dotted lines indicate thick disks with a scale length two times larger than that of the thin disk. Triangle symbols stand for the second truncation in Type II+II and Type II+III+II profiles. Error bars represent 2σ fitting errors.

Further away and larger samples - Gaia-ESO



Lack of alpha-enhanced stars in the outer disk!