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Exploring the diffuse interstellar bands with the Sloan Digital Sky Survey

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Abstract & Introduction

We use star, galaxy and quasar spectra taken by the Sloan Digital Sky Survey to map out the distribution of diffuse interstellar bands (DIBs) induced by the Milky Way. After carefully removing the intrinsic spectral energy distribution of each source, we show that by stacking thousands of spectra, it is possible to measure statistical flux fluctuations at the 10^{-3} level, detect more than 20 DIBs and measure their strength as a function of position on the sky. We create a map of DIB absorption covering about 5000 deg^2 and measure correlations with various tracers of the interstellar medium: atomic and molecular hydrogen, dust and polycyclic aromatic hydrocarbons (PAHs). After recovering known correlations, we show that each DIB has a different dependence on atomic and molecular hydrogen: while they are all positively correlated with $N_{\rm HI}$, they exhibit a range of behaviours with $N_{\rm H_2}$ showing positive, negative or no correlation. We show that a simple parametrization involving only $N_{\rm HI}$ and $N_{\rm H_2}$ applied to all the DIBs is sufficient to reproduce a large collection of observational results reported in the literature: it allows us to naturally describe the relations between DIB strength and dust reddening (including the so-called skin effect), the related scatter, DIB pair-wise correlations and families, the affinity for σ/ζ-type environments and other correlations related to molecules. Our approach allows us to characterize DIB dependencies in a simple manner and provides us with a metric to characterize the similarity between different DIBs.

Key words: methods: statistical – surveys – ISM: lines and bands – ISM: molecules.

- SDSS のデータを使って diffuse interstellar band (DIB) の性質を調べた
- stars, quasars, red galaxies のスペクトルをまとめて DIB の強度分布を調べた
- dust (IRAS 100μm), PAH (WISE 12μm), HI (21cm), H_2 ($CO_{1\text{-}0}$) との相関を調べた
- DIB の強度を HI, H_2 の 2 変数関数として表現 → そこそこうまくいく
- DIB の性質 (キャリア分子のファミリー) を調べるための良い指標になるか？

Figure 2: Quasar のスペクトル

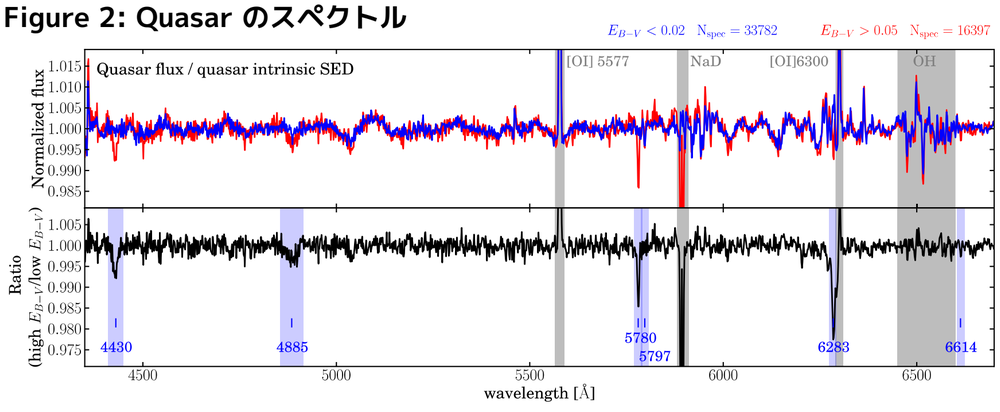

Figure 4: SDSS のデータからコンパイルした可視 DIB スペクトル

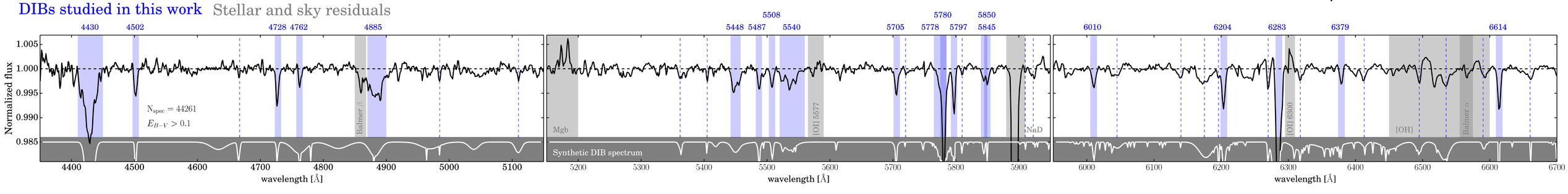

Figure 6: DIB の強度分布 (~ダスト分布)

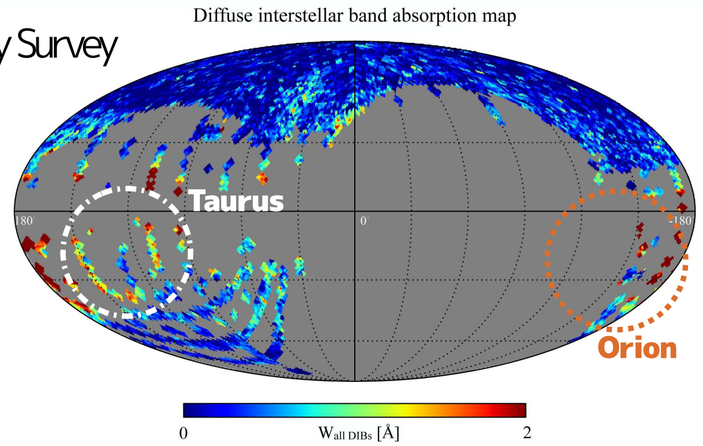

Figure 12: DIB の強度と HI, H_2 の関係

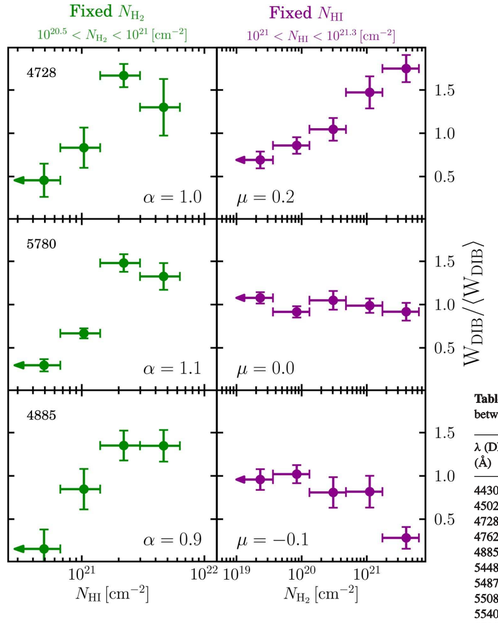

Figure 8: 各 DIB の強度と減光量の関係

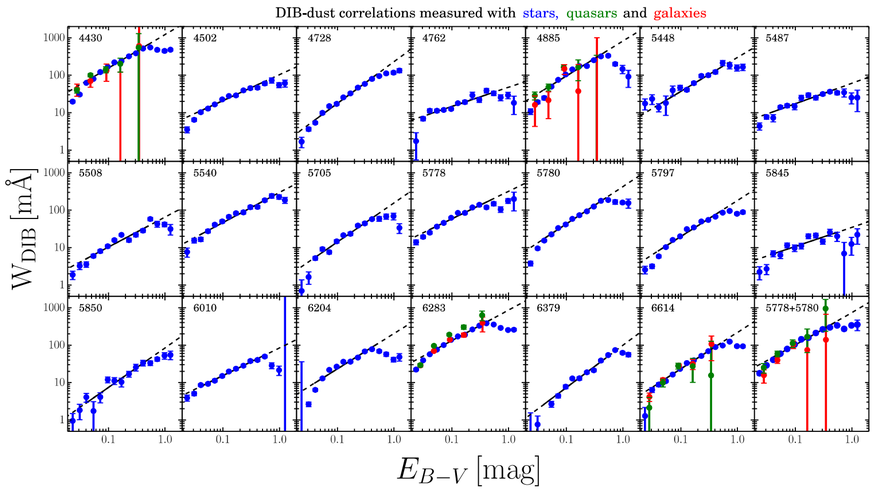

Figure 13: HI,H_2 の依存性から分類した (α,μ) 空間での分布

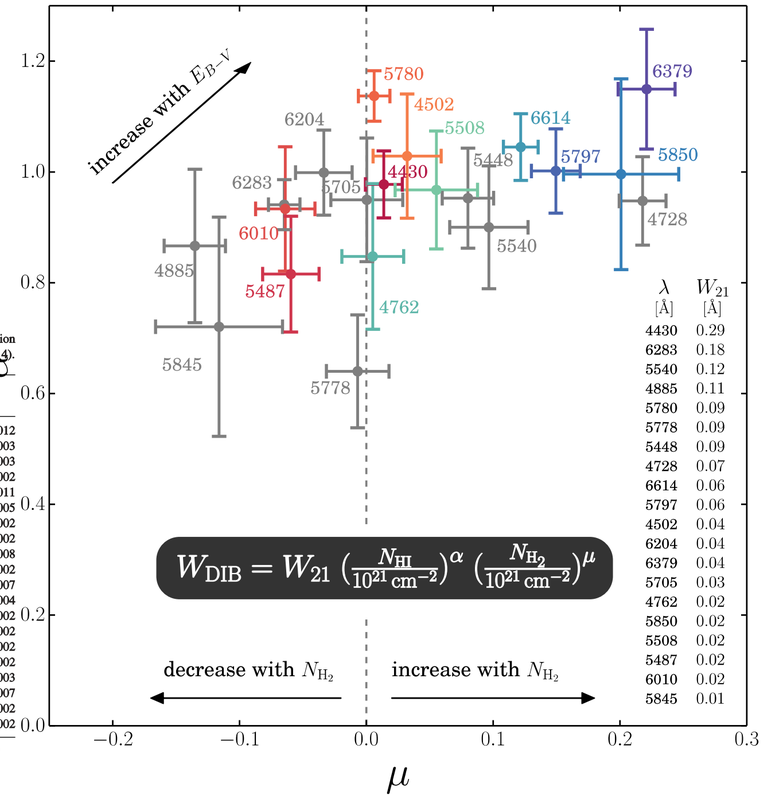

Table 4. Best-fitting parameters characterizing the relation between DIBs and hydrogen column densities (equation 4).

λ (DIB) (Å)	α (H_1) –	μ (H_2) –	W_{21} (Å)
4430	0.98 ± 0.06	$+0.01 \pm 0.01$	0.287 ± 0.012
4502	1.03 ± 0.10	$+0.03 \pm 0.03$	0.038 ± 0.003
4728*	0.95 ± 0.09	$+0.22 \pm 0.02$	0.070 ± 0.003
4762	0.85 ± 0.12	$+0.01 \pm 0.03$	0.024 ± 0.002
4885*	0.87 ± 0.13	-0.14 ± 0.03	0.111 ± 0.011
5448*	0.95 ± 0.09	$+0.08 \pm 0.02$	0.087 ± 0.005
5487	0.82 ± 0.12	-0.06 ± 0.03	0.021 ± 0.002
5508	0.97 ± 0.12	$+0.06 \pm 0.04$	0.022 ± 0.002
5540*	0.90 ± 0.11	$+0.10 \pm 0.03$	0.118 ± 0.008
5705*	0.95 ± 0.11	$+0.00 \pm 0.03$	0.028 ± 0.002
5778*	0.64 ± 0.11	-0.01 ± 0.03	0.089 ± 0.007
5780	1.14 ± 0.05	$+0.01 \pm 0.01$	0.089 ± 0.004
5797	1.00 ± 0.07	$+0.15 \pm 0.02$	0.058 ± 0.002
5845*	0.72 ± 0.21	-0.12 ± 0.05	0.010 ± 0.002
5850	1.00 ± 0.15	$+0.20 \pm 0.04$	0.024 ± 0.002
6010	0.93 ± 0.13	-0.06 ± 0.02	0.020 ± 0.002
6204*	1.00 ± 0.08	-0.03 ± 0.02	0.037 ± 0.003
6283*	0.94 ± 0.05	-0.06 ± 0.01	0.177 ± 0.007
6379	1.15 ± 0.11	$+0.22 \pm 0.02$	0.035 ± 0.002
6614	1.04 ± 0.06	$+0.12 \pm 0.01$	0.063 ± 0.002

Note. *DIBs possibly blended with multiple weak DIBs.

λ [Å]	W_{21} [Å]
4430	0.29
6283	0.18
5540	0.12
4885	0.11
5780	0.09
5778	0.09
5448	0.09
4728	0.07
6614	0.06
5797	0.06
4502	0.04
6204	0.04
6379	0.04
5705	0.03
4762	0.02
5850	0.02
5508	0.02
5487	0.02
6010	0.02
5845	0.01