SED and emission line properties of low-z red 2MASS AGN

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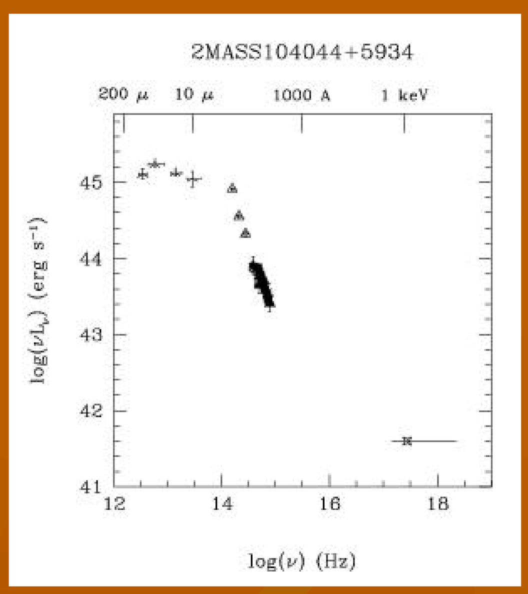
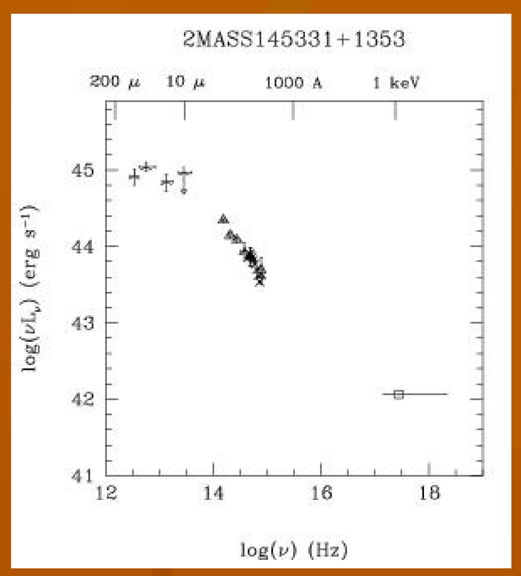


Abstract

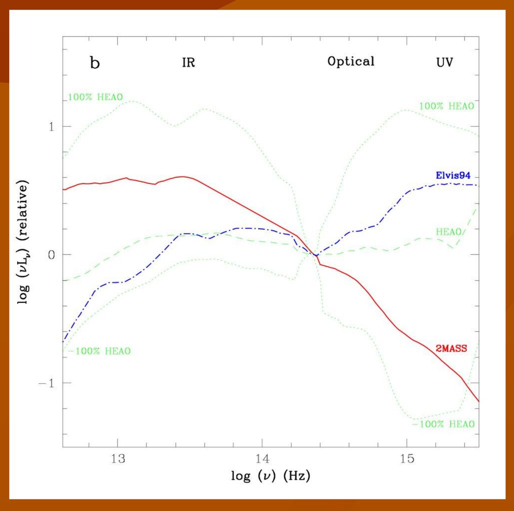
Radio and far-IR surveys, and modeling of the cosmic X-ray background suggest that a large population of obscured AGN has been missed by traditional, optical surveys. The Two Micron All-Sky Survey (2MASS) has revealed a large population of mostly nearby red, moderately obscured AGN, among which 75% are previously unidentified emission-line AGN, with 85% showing broad emission lines. We present the SED and emission line properties of 44 such red (J-Ks>2) 2MASS AGN observed with Chandra. Their IR-to-X-ray spectral energy distributions (SEDs) are red in the near-IR/opt/UV showing little or no blue bump. The optical colors are affected by reddening, host galaxy emission, redshift, and in few, highly polarized objects, also by scattered AGN light. The levels of obscuration obtained from optical, X-rays, and far-IR imply N_H < few$*10^{22}$ cm^{-2}. This, combined with the distribution of [OIII]5007 emission line equivalent widths, suggest a predominance of inclined objects in which obscuration/inclination allows us to see and study weaker emission components which are generally swamped by the direct AGN light. PCA analysis of the IR-X-ray SED and emission line properties shows that, while obscuration/inclination is important, the dominant cause of variance in the sample (eigenvector~1) is the L/Ledd ratio (perhaps because the red near-IR selection limits the range of inclination/obscuration values in our sample). This analysis also distinguishes two sources of obscuration: the host galaxy and circumnuclear absorption.



Sample

44 AGN from the 2MASS survey with red J-K_S > 2 colors and observed by Chandra. Redshift range: z < 0.37, full range of spectral types (1→intermediate→2), K_S-to-X-ray slopes, and polarization (0–13%).

Median Spectral Energy Distribution



Comparison between 2MASS AGN median SED (in red), blue optically and radio selected AGN from Elvis et al. 1994 (unobscured AGN with $N_H < 10^{21}$ cm^{-2}, in blue), and HEAO hard-X-ray selected AGN (Kuraszkiewicz et al. 2003; sample representative of the real AGN population, as it is less biased by the affects of obscuration along the line of sight; in green).

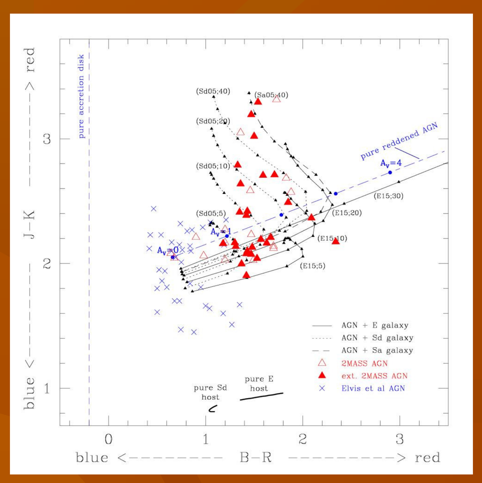
Red 2MASS median SED is:

- redder in near-IR (due to the red J–K_S>2 selection)
- redder in opt/UV (B−R lower by ~1mag.)
- has little/no blue bump

Analysis of optical/IR colors

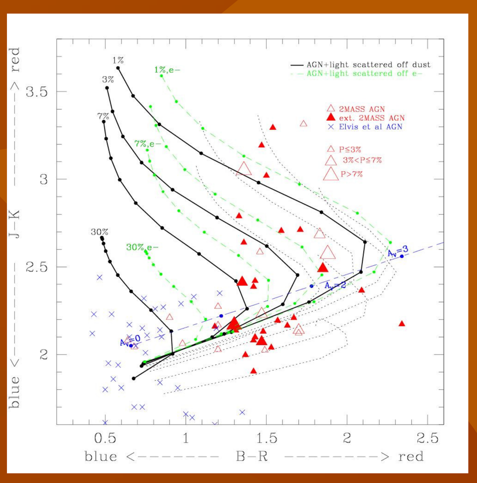
Why are the optical/near-IR colors so red?
B−R color affected by:

– host galaxy :



Effects of host galaxy on AGN colors: reddened (A_V=0→10mag) Elvis et al. (1994) median AGN SED + host galaxy templates from Buzzoni (2005). Solid lines: AGN + elliptical host with 15 Gyrs stars (E15), dotted lines: AGN + Sd host with 5 Gyrs stars (Sd05) .

– scattered light :



Effects of scattered light on AGN colors: reddened (A_V = 0→10mag) Elvis et al. (1994) median AGN SED + AGN intrinsic light scattered on dust (solid line; Drain 2003 scattering model, θ=90°) and electrons (green dashed line).

Summary of the J-K_s vs B-R color-color modeling

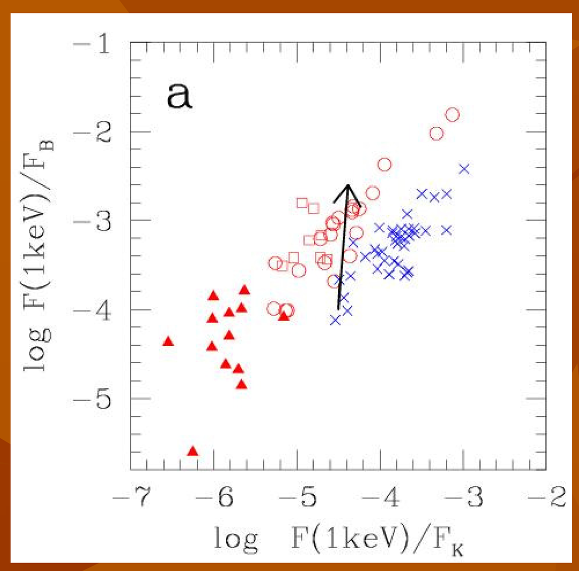
Type	AGN Reddening	Host galaxy contribution at R	Why J-K_S red?
1	A_V < 1	0%	Hot circumnuclear dust emission
1.2-1.5	1 < A_V < 5	30-50%	reddened AGN
1.8-1.9	3 < A_V <10	> 80%	reddened AGN
2	7 < A_V <22	100%	reddened AGN

- 8 Type 1.2→1.9 modeled together with a scattered light component, where <2% of intrinsic AGN light is scattered towards us
- N_H~10^{22} cm^{-2} low for Type2s→absorber in inclined host galaxy (Malizia et al. 1997)
- A_V agrees with N_H from X-rays (unusual see Maiolino et al. 2001).

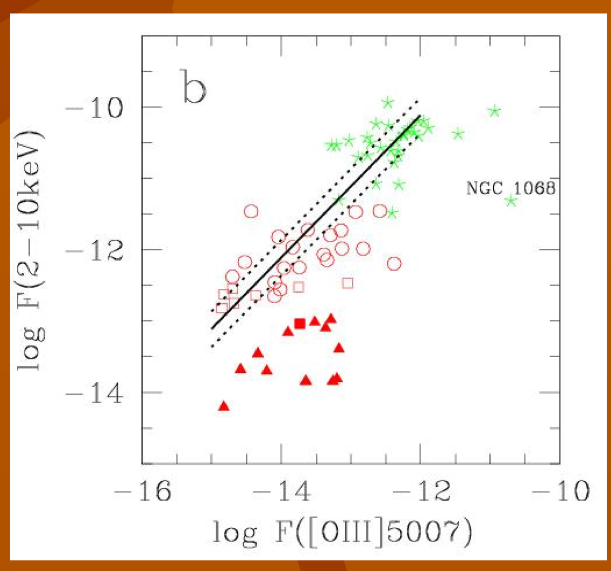
X-ray properties

1/3 of sample shows:

10-100x lower F(1keV)/FK ratios than the blue optically/radio selected AGN from Elvis et al. (1994; blue crosses):

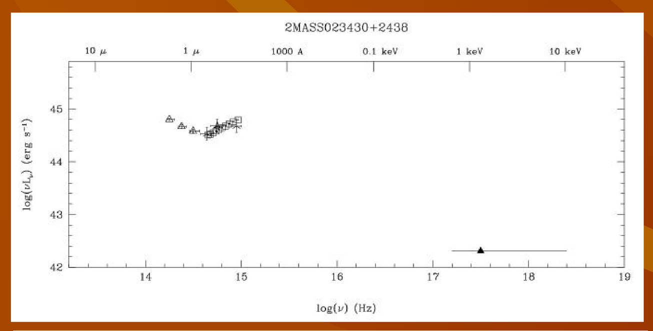


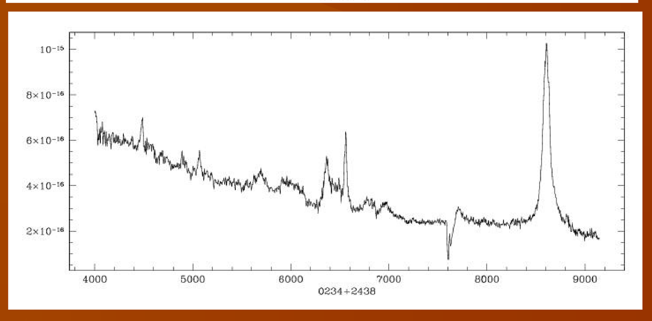
10-100x lower F(2--10keV)/F([OIII]) ratios than those found in Seyfert 1s and 2s (Mulchaey et al 1994; green stars):



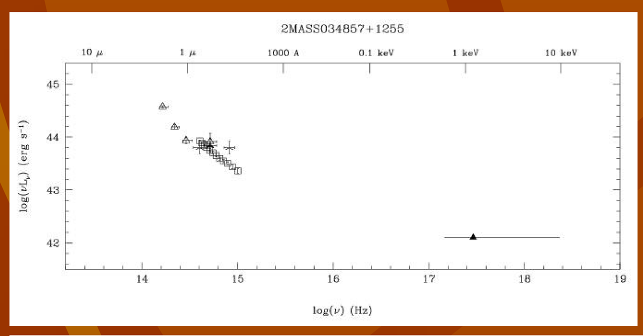
X-ray weak sources include:

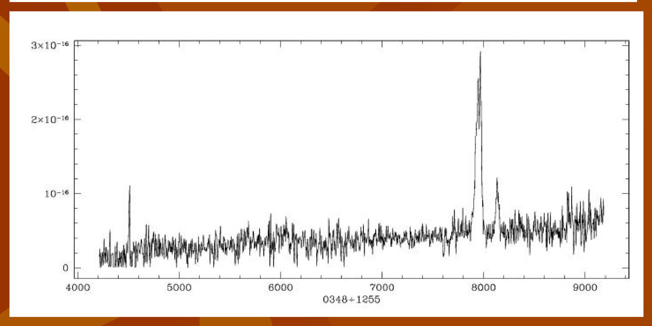
1. intrinsically X-ray weak sources – with relatively blue B−R and J−K_S colors (due to unreddened $A_V \leq 1$ mag AGN) and NLS1/BALQSO optical spectra → high L/L_{Edd}:





2. highly obscured sources – with red B−R and J−K_S colors due to high reddening (A_V=10–15mag) and large (96-100%) host galaxy contribution at R band:

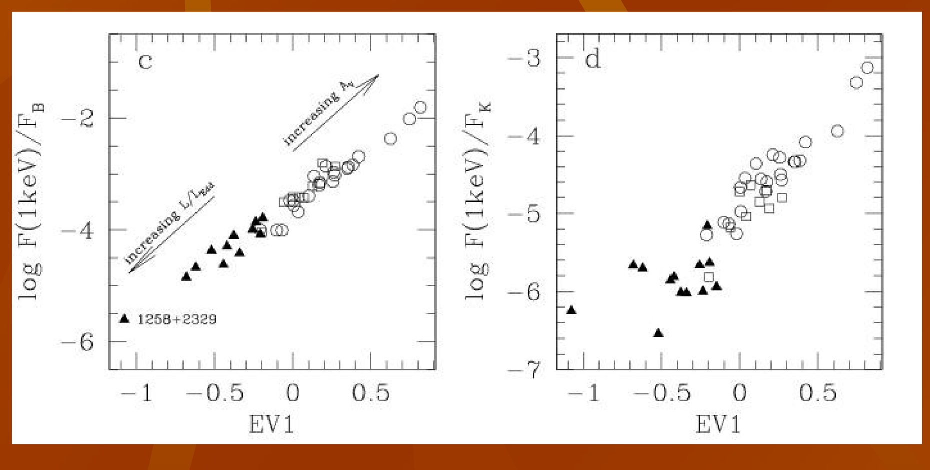


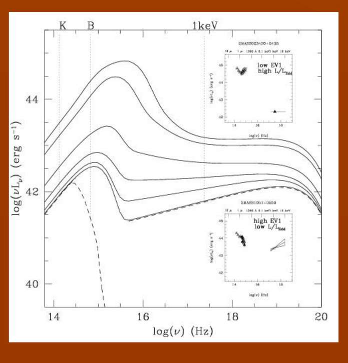


The red J–K_S selection finds sources in which circumnuclear dust emission (Type 1) or host galaxy obscuration (Type 1.2-2) result in unusually red near-IR colors. Those objects which are obscured, most likely viewed at an intermediate angle, offer an opportunity to study the contributions of weaker emission components, such as host galaxy and scattered light emission, which are normally outshone by the AGN direct light.

PCA analysis – run on the SED parameters shows that 70% of variance in sample is explained by 4 eigenvectors, each having a physical explanation:

Eigenvector 1 (33% of variance) - L/L_{Edd} + reddening - correlates with F(1keV)/$F_{B,R,I,J,K}$ and F(2-10keV)/F([OIII])**:**





Accretion disk + accreting corona model of Witt, Czerny & Zycki (1996).

Negative EV1:

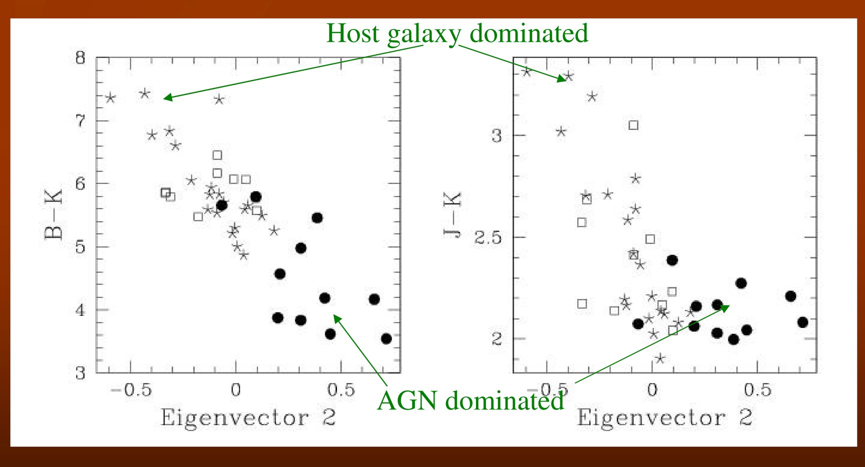
- big blue bump, low A_V
- weak X-rays
- NLS1/BALQSO opt. spectra

Positive EV1:

- no blue bump (N_H~10^{22} cm^{-2})
- strong X-rays
- Type 1.9 → 2 optical spectra

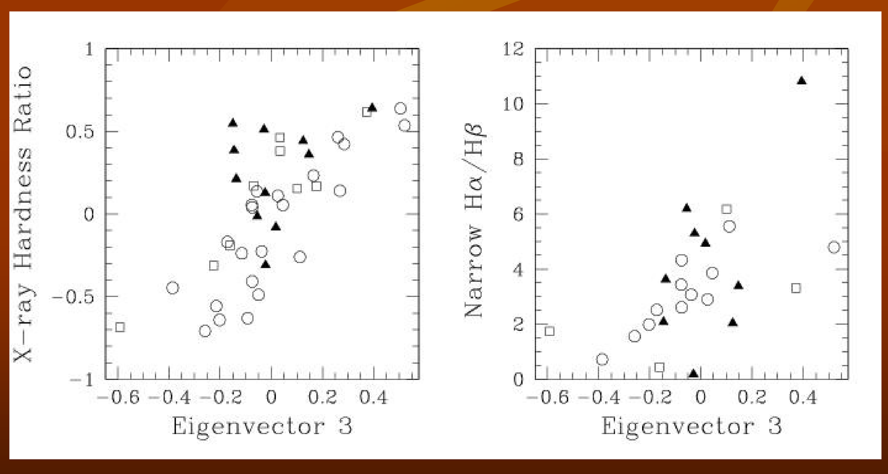
Eigenvector 2 (18% of variance) - host galaxy contribution

Correlates with: B-K_S, B-R, J-K_S and optical spectral type EV2 depends on host galaxy to observed/reddened AGN ratio



Eigenvector 3 (12% of variance) – host galaxy absorption

Correlates with: X-ray hardness ratio, Γ_X , N_H, and narrow Hα/Hβ → common absorber for the optical and X-rays → dust in an inclined host galaxy.



Eigenvector 4 (8 % variance) – circumnuclear dust obscuration

Correlated with degree of optical polarization and broad Hα/Hβ → same dust scatters the intrinsic AGN continuum + broad emission lines and reddens the broad emission lines