# X-ray emission from the young brown dwarfs of the Taurus Molecular Cloud

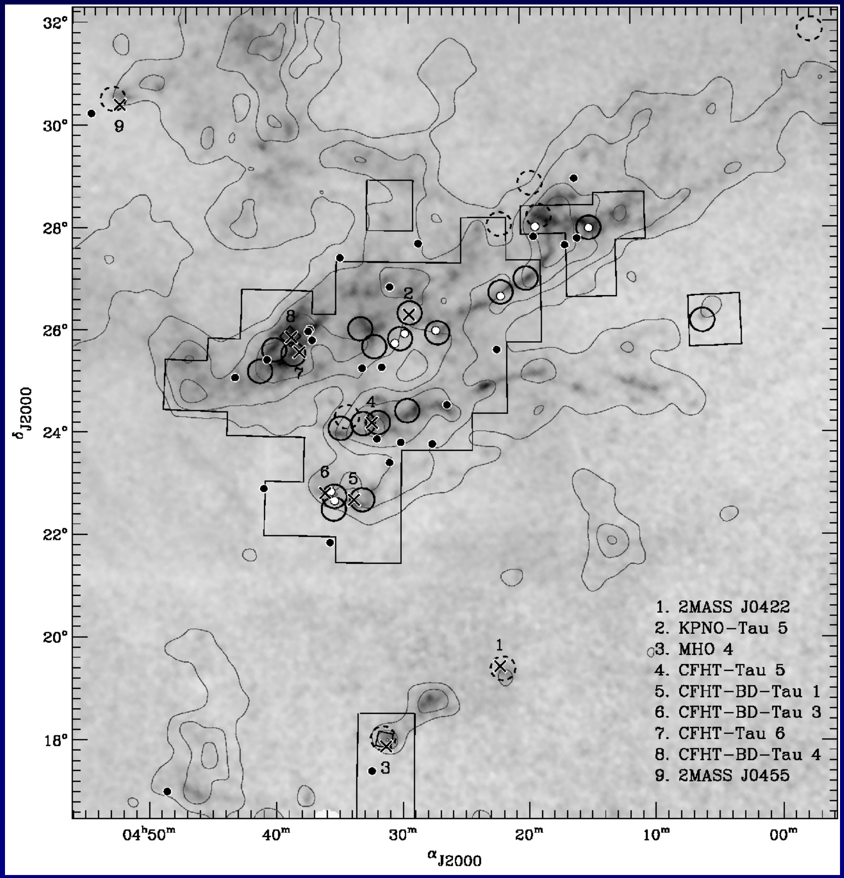
N. Grosso[1], K. R. Briggs[2], M. Güdel[2], S. Guieu[1], E. Franciosini[3], F. Palla[4], C. Dougados[1], J.-L. Monin[1,5], F. Ménard[1], J. Bouvier[1], M. Audard[6], and A. Telleschi[2]

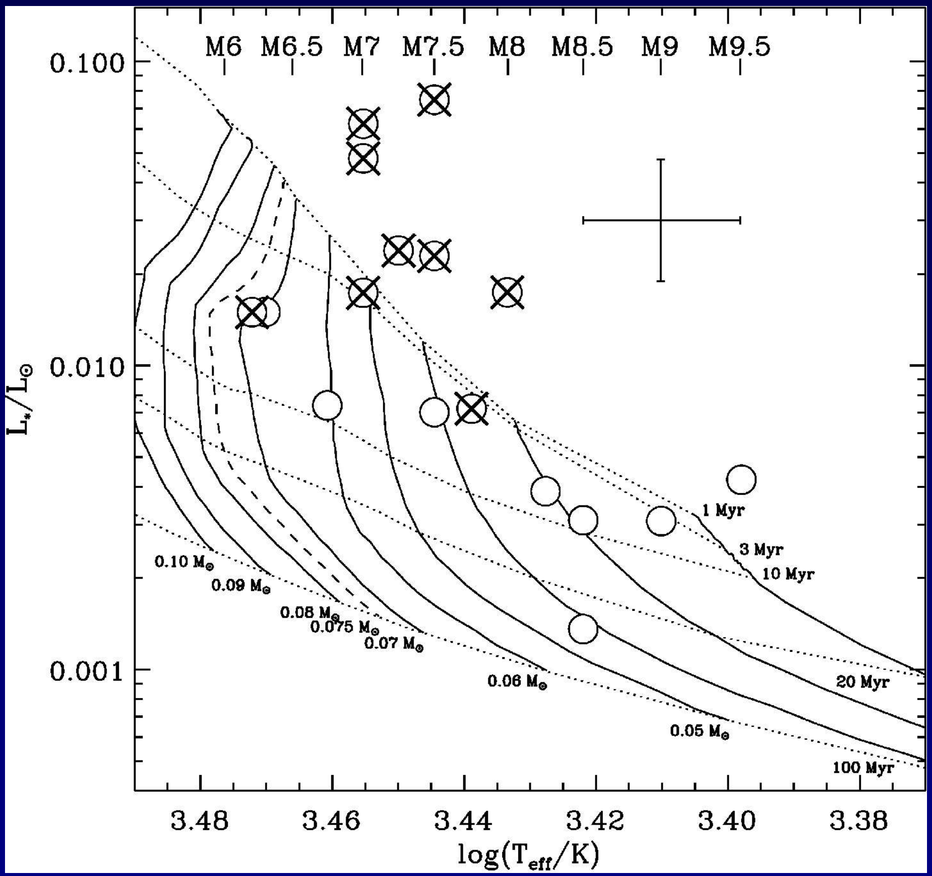
[1] Laboratoire d'Astrophysique de Grenoble, Université Joseph-Fourier, F-38041 Grenoble cedex 9, France
e-mail: Nicolas.Grosso@obs.ujf-grenoble.fr
[2] Paul Scherrer Institut, 5232 Villigen und Würenlingen, Switzerland
[3] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[4] INAF - Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, I-50125 Firenze, Italy
[5] Institut Universitaire de France
[6] Columbia Astrophysics Laboratory, Columbia University, 550 West 120th Street, New York, NY 10027, USA

Astronomy & Astrophysics, 2006, in press [astro-ph/0608696]

# The X-ray Emission Survey of the Taurus Molecular Cloud (XEST)

- 27 *XMM-Newton* fields of view.

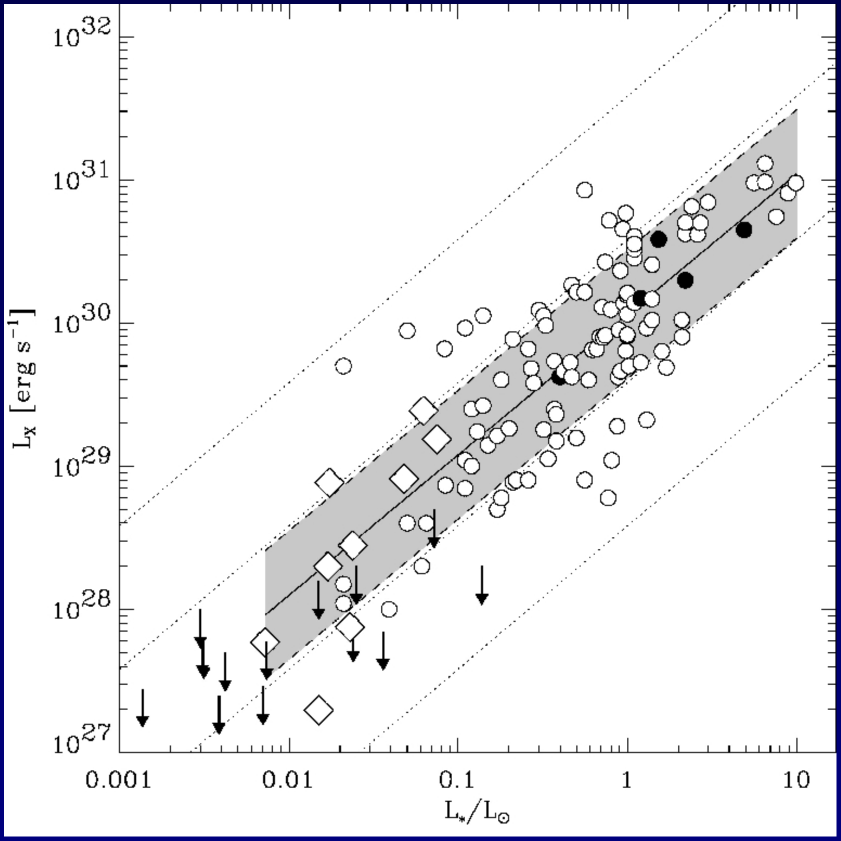



- Brown dwarf (BD): object with mass lower than the hydrogen burning limit (~0.075 solar mass).
- 42 young BDs in this area (Briceño et al. 1998, 2002; Luhman 2000, 2004, 2006; Martín et al. 2001; Guieu et al. 2006).
- 17 BDs surveyed by 15 *XMM-Newton* pointings and one archival *Chandra* pointing:
  - 8 BDs not detected (white dots);
  - 9 BDs detected (crosses); only 2 BDs of the TMC (MHO 4, CFHT-BD-Tau 4) were previously detected by *ROSAT*.

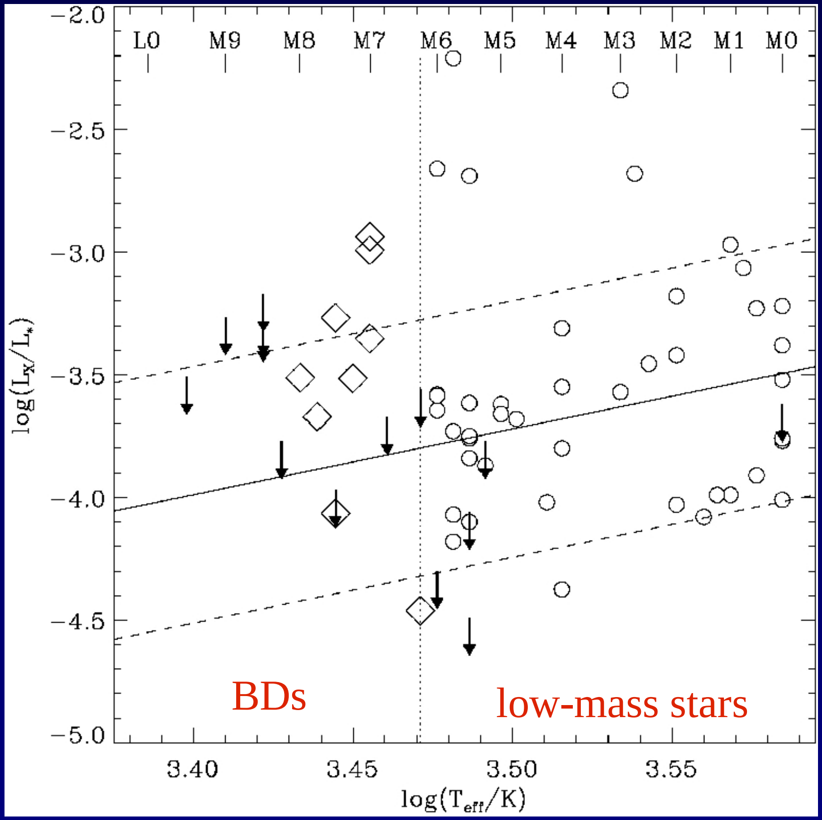
The detection rate of young BDs in the XEST is 53%.

# X-ray luminosity vs. bolometric luminosity



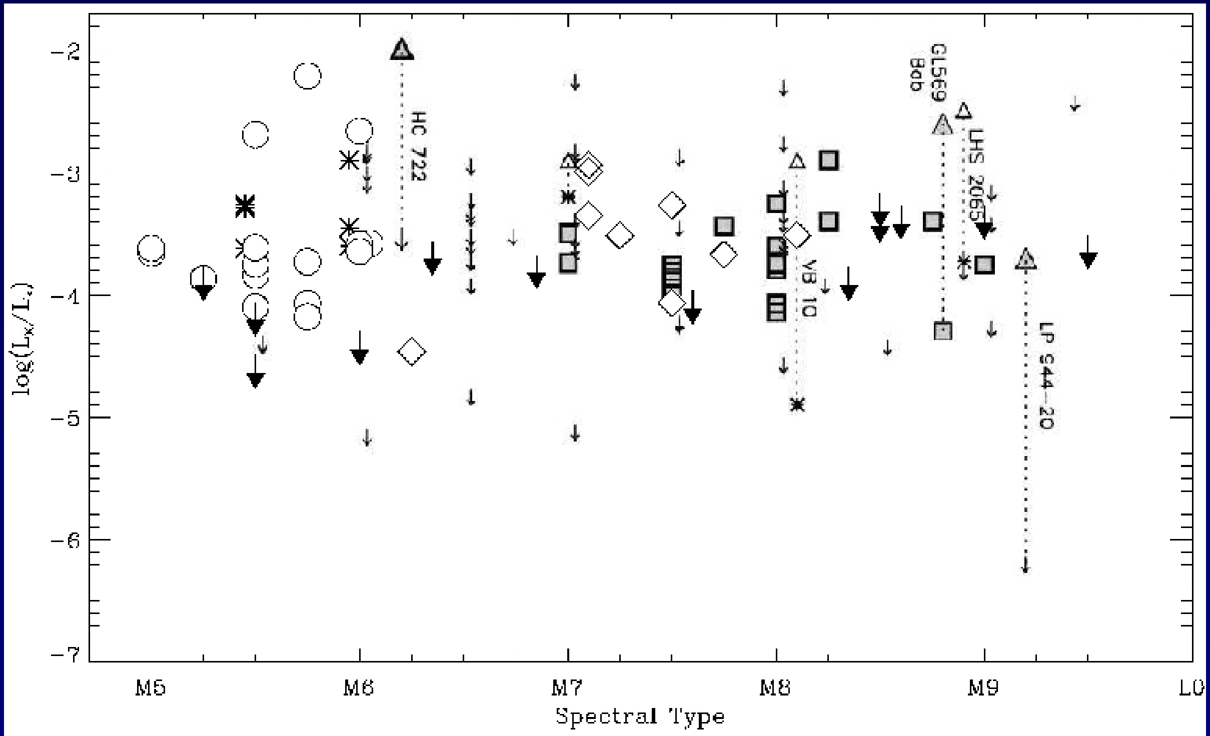

- log $(L_X/\mathrm{erg\ s^{-1}})=(30.06\pm0.05) + (0.98\pm0.06)\mathrm{x}\log(L_*/L_\odot)$ for *detected* BDs and low-mass (proto)stars.
- This relation is consistent with $\langle\log (L_X/L_*)\rangle=-3.5 \pm 0.4$.
- For the XEST brown dwarfs, the median of $\log (L_X/L_*)$ (including upper limits) is -4.0.

# X-ray fractional luminosity vs. effective temperature




- Linear regression fit including upper limits ($P(0)<0.11$): $\log(L_X/L_*)=(-13.1\pm5.4) + (2.7\pm1.5)\times\log(T_{eff}/K)$.
- The X-ray fractional luminosity decreases by a factor of about 3 from hot coronae of solar-mass stars to cooler atmospheres of M9V BDs.

# X-ray fractional luminosity vs. spectral type for objects of type M5 and later (field dwarfs and young BDs)




- Asterisks = late M field stars (Fleming et al. 1993).
- Circles = low-mass stars of the TMC detected in X-rays (Güdel et al. 2006).
- Diamonds and thick arrows = BDs in the TMC.
- Filled squares = other X-ray detected BDs (Preibisch et al. 2005, and references therein)

- Objects of spectral type M7 with an age of 1 Gyr are not BDs, but low-mass stars twice as massive as a typical TMC BD having an M7 spectral type and an age of 3 Myr. Moreover, such very cool stars also have surface gravities about 40 times higher than in a typical TMC BD.
- The X-ray activity of BD coronae is not strongly dependent of the BD mass and the BD surface gravity.
- The relation between X-ray activity and effective temperature agrees with the overall result: of the 15 sources shown with spectral types M8.5V or later, only 4 have any detected quiescent emission; the rest are either not detected at all or (in 3 cases) detected only during strong flares.

# Conclusions

• No dramatic change of the magnetic activity at the stellar/substellar boundary. Young BDs of spectral type M are sufficiently warm to sustain an active corona. The young BDs in the TMC, with a median spectral type of M7.5, have on average an X-ray surface flux ($L_X/4\pi R_*^2$) which is 7 times higher than the one observed in the solar corona at the solar cycle maximum.

• No significant log-log correlation between the X-ray fractional luminosity and EW(H$\alpha$).
• Accreting and nonaccreting BDs in the TMC have a similar X-ray fractional luminosity.
• The TMC BDs are 1.6 times more active in X-rays than BDs in the *Chandra Orion Ultradeep Project* (COUP).

Deeper X-ray observations of the coolest M-type BDs in the TMC are needed to investigate a possible turn-over of the fractional X-ray luminosity of TMC BDs around spectral type M9V.