Energy Dispersive X-ray Absorption Spectroscopy: Scientific Opportunities and Technical Challenges

Alain Fontaine

2007

1999

Michael Hagelstein
Alfonso San Miguel
Sakura Pascarelli
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ID24 *Alain Fontaine* D11

EXAFS and Near Edge Structure

Proceedings of the International Conference
Frascati, Italy, September 13–17, 1982

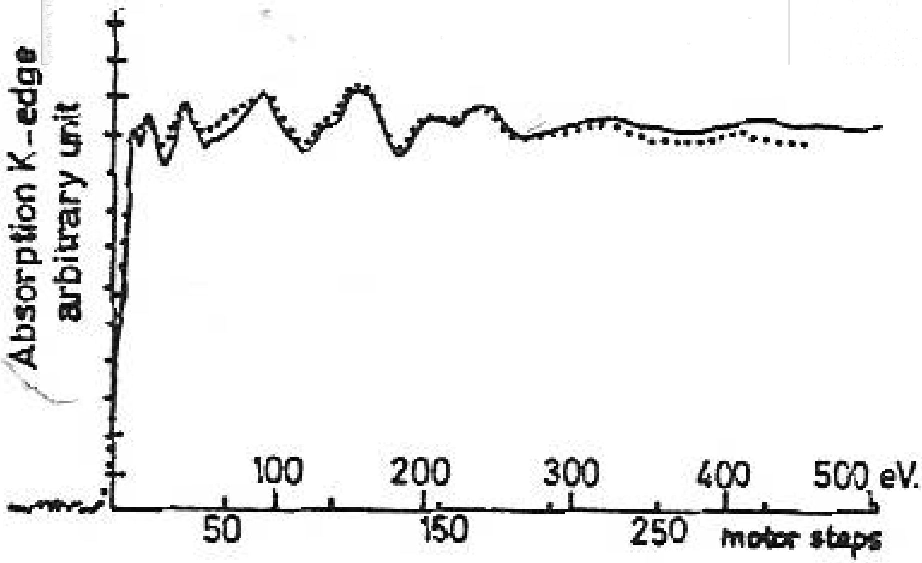
Editors:
A. Bianconi L. Incoccia S. Stipcich

With 316 Figures

Time-Resolved EXAFS

A.M. Flank[1], A. Fontaine[2], A. Jucha, M. Lemonnier,
and C. Williams[3]

LURE, CNRS, Bât. 209c, F-91405 Orsay-Cedex, France



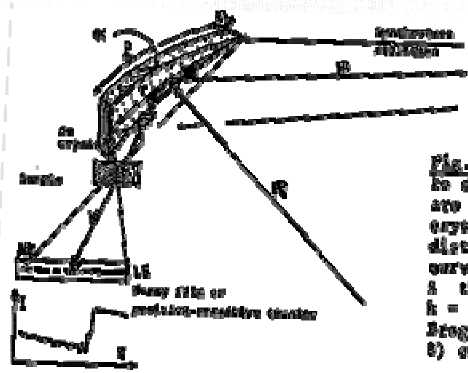


Fig.1 The relevant parameters to describe the curved crystal are p and p' the source to crystal and crystal to focus distances, R the radius of curvature of the crystal, ℓ the length ... h = θ−α are the angles of the Bragg reflection (defined by θ) on a blade cut asymmetrically

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X-RAY ABSORPTION IN DISPERSIVE MODE: A NEW SPECTROMETER AND A DATA ACQUISITION SYSTEM FOR FAST KINETICS

E. DARTYGE, C. DEPAUTEX, J.M. DUBUISSON, A. FONTAINE, A. JUCHA, P. LEBOUCHER and G. TOURILLON

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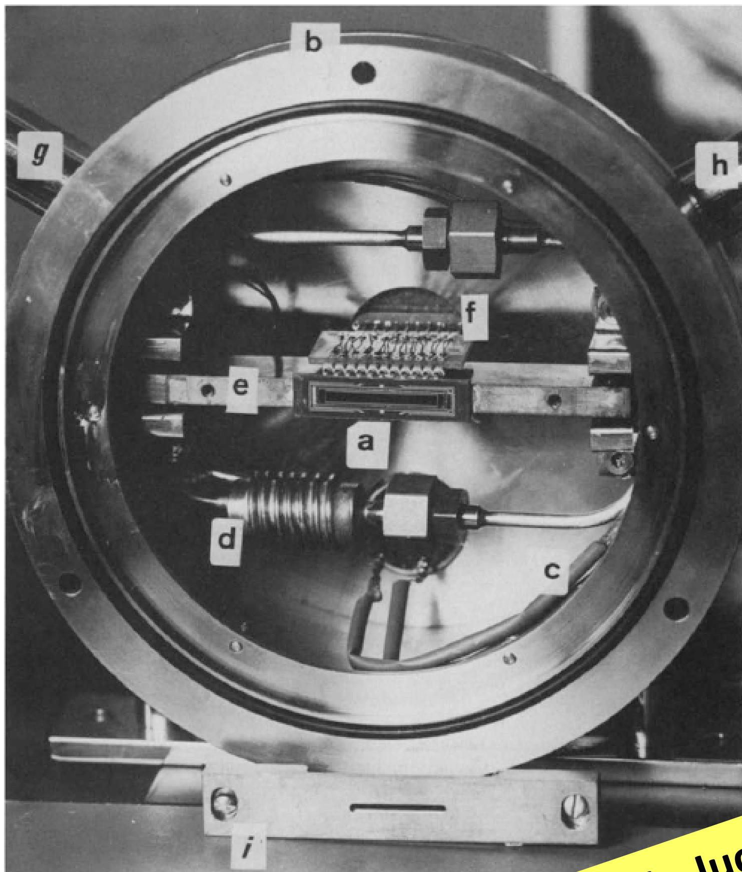

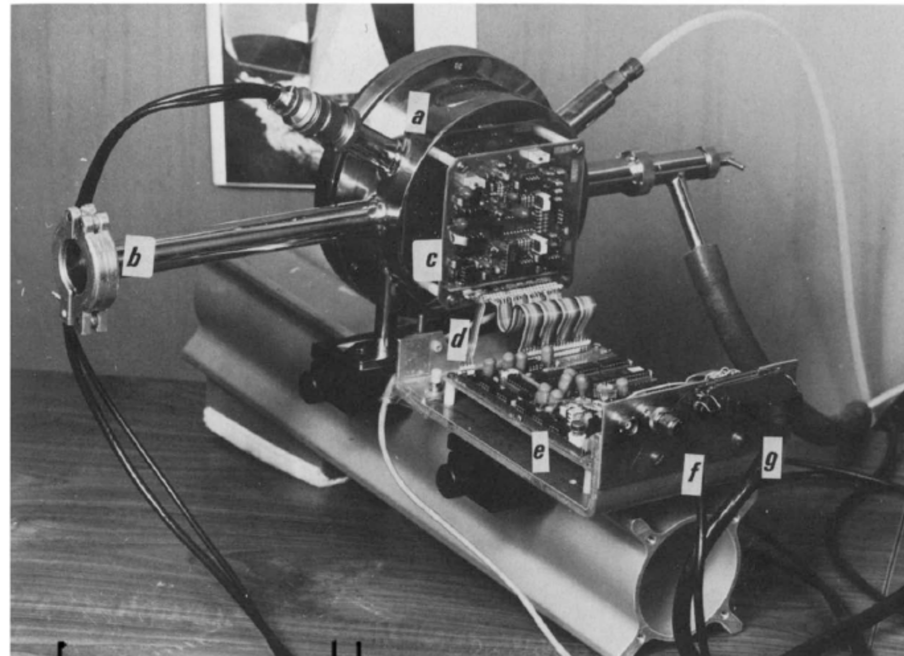

Alain Jucha

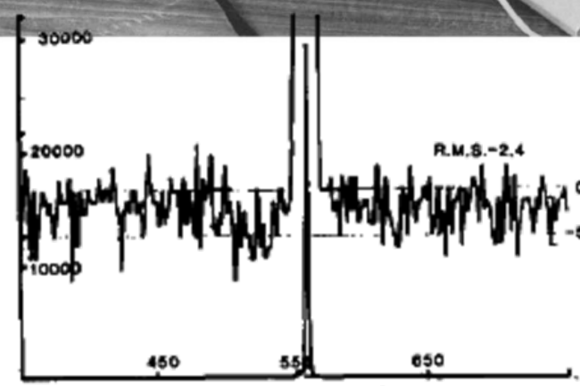

Fig. 4. The response of the photodiode array to a 10 μm wide beam gives evidence of the 50 μm spatial resolution since dots are 50 μm apart. The drawing is produced for odd diodes for the sake of clarity. The dynamics is better than 10^4.

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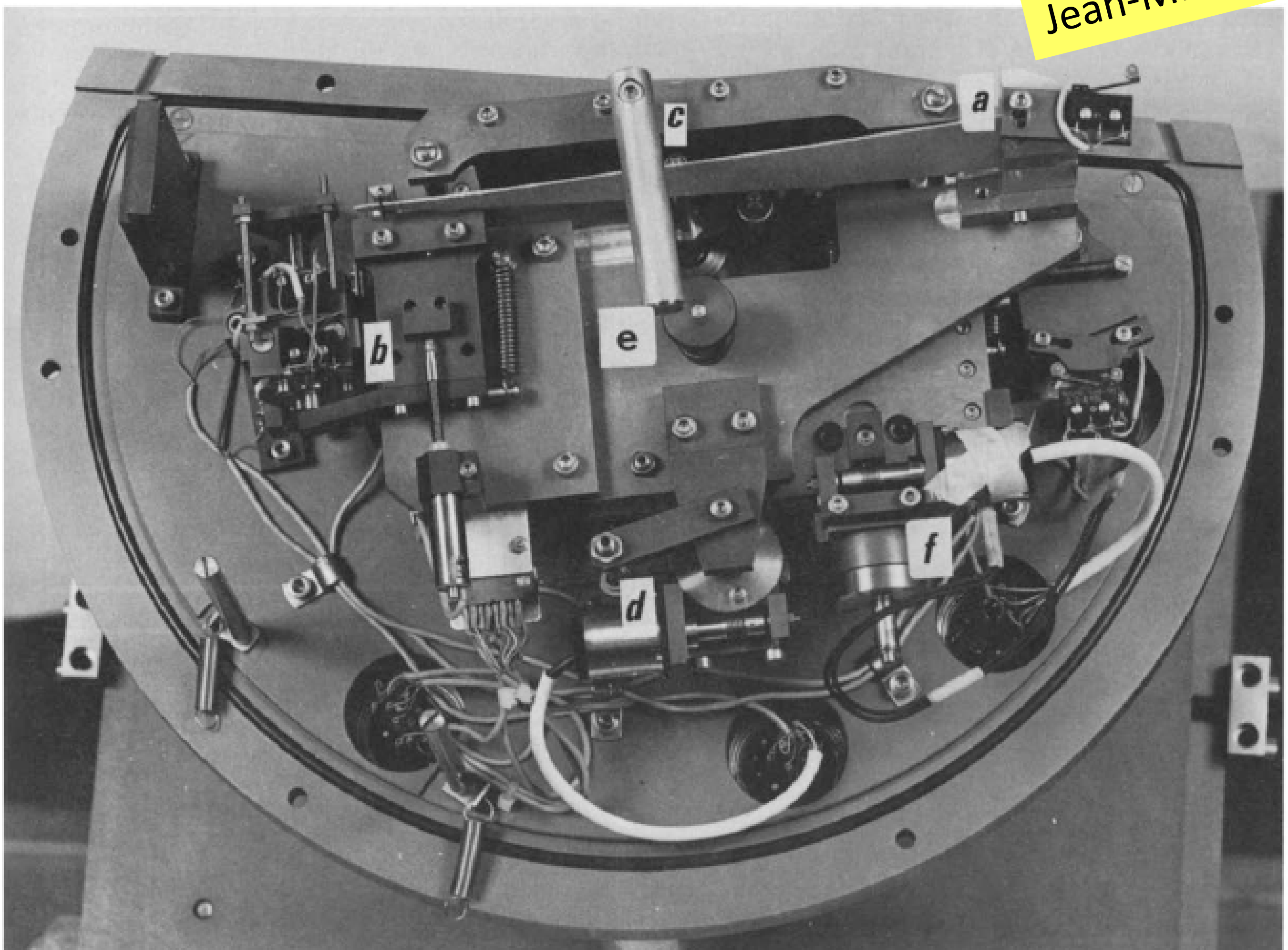
Jean-Michel Dubuisson



ABERRATION-FREE AND HARMONIC-FREE OPTICS FOR TIME-RESOLVED X-RAY ABSORPTION SPECTROSCOPY USING SYNCHROTRON RADIATION

H. TOLENTINO, F. BAUDELET, E. DARTYGE, A. FONTAINE, A LENA and G. TOURILLON
LURE, CNRS, Bat. 209 D, F91405 Orsay Cedex, France

Received 30 May 1989 and in revised form 15 September 1989

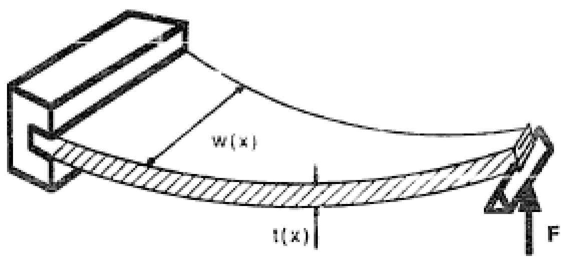
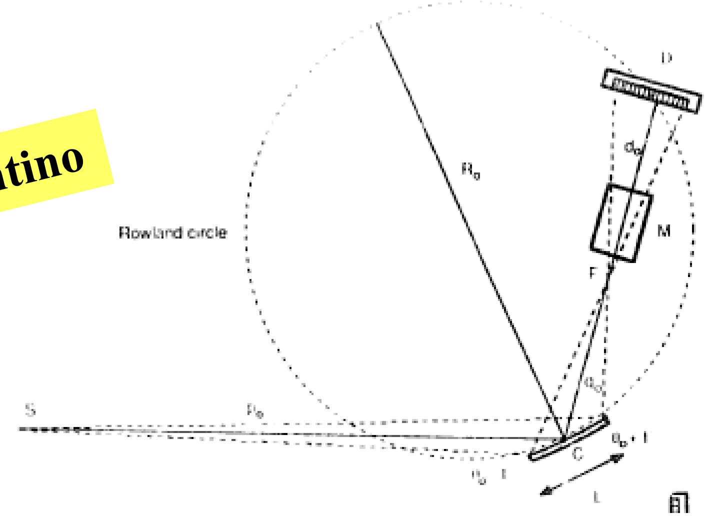
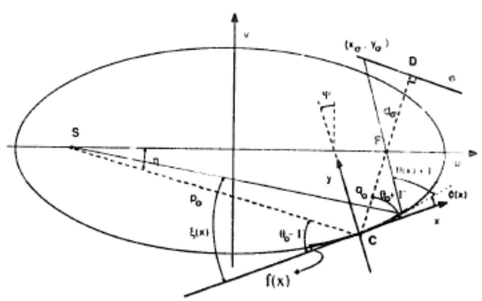


Fig. 3. Crystal bending device: the base of the crystal is clamped and a screw-driven force is applied to the apex.

Hélio Tolentino





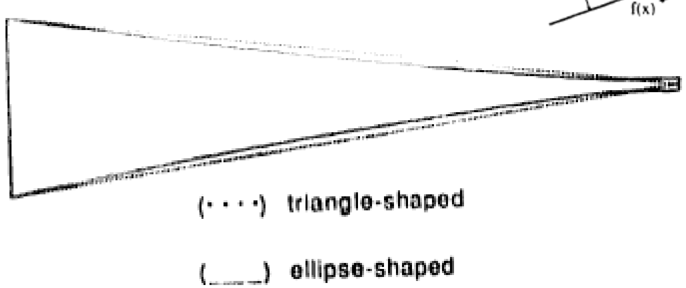
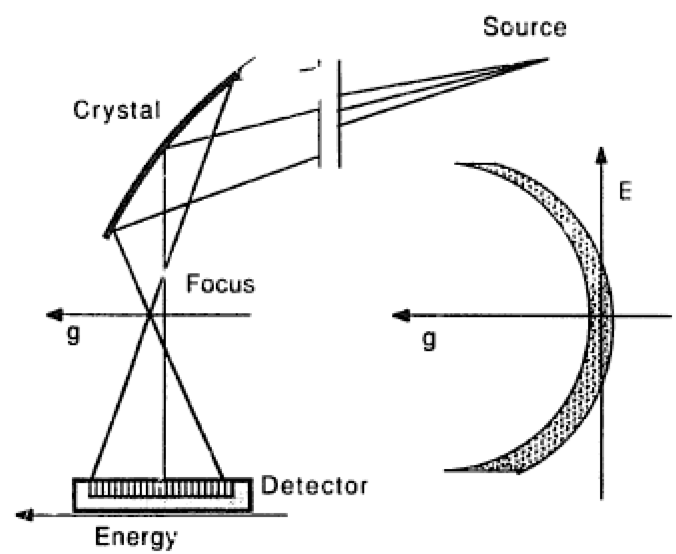
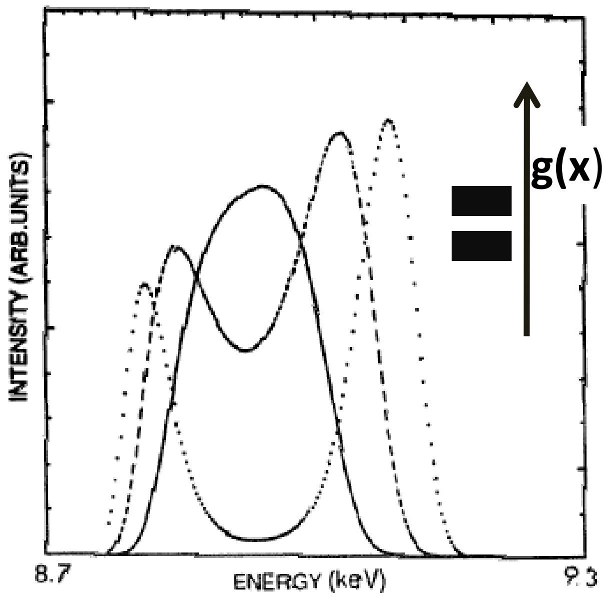
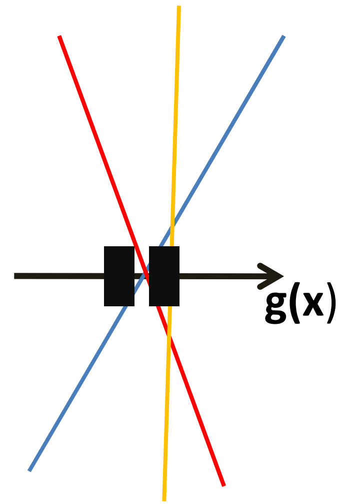
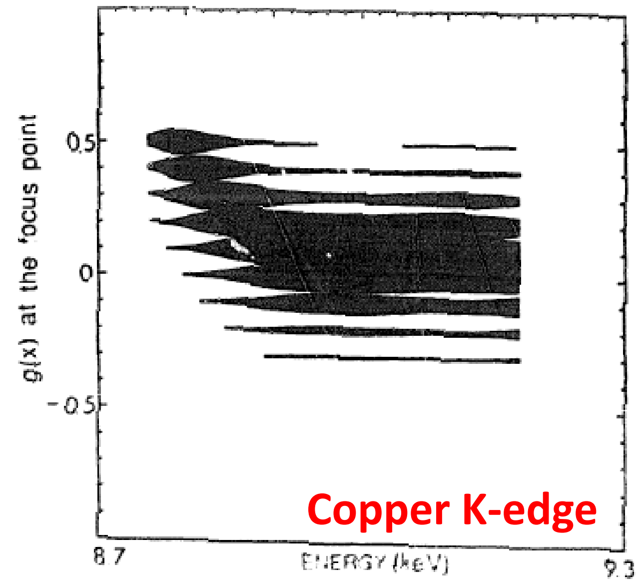


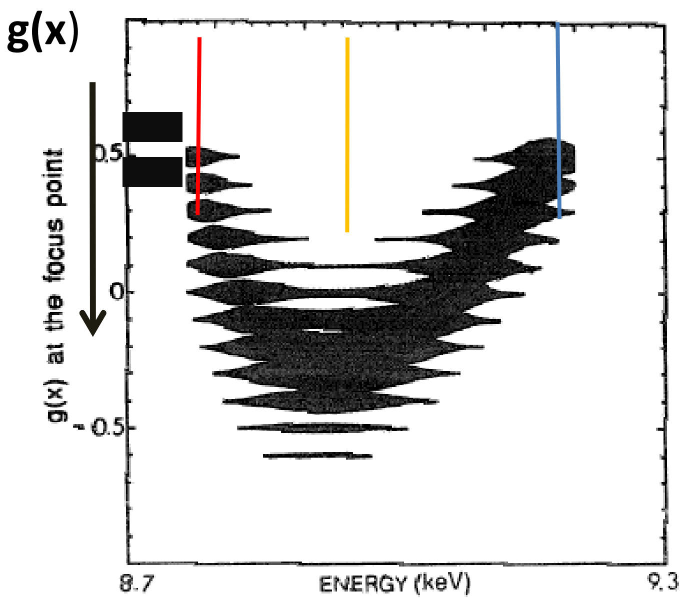
Fig. 6. (· · · · · ·) Triangle-shaped crystal and (———) correction to the linear variation of the width. The crystal is shaped to provide an ideal focus from 90% of the full length.

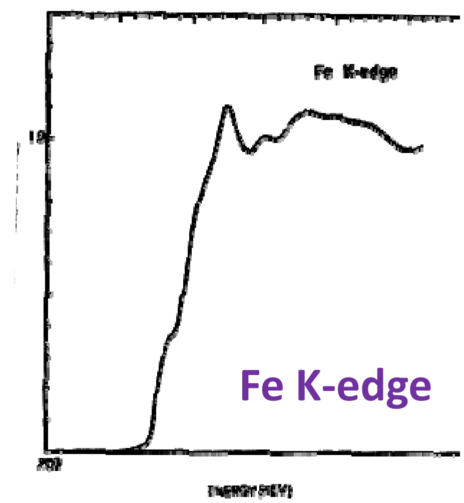




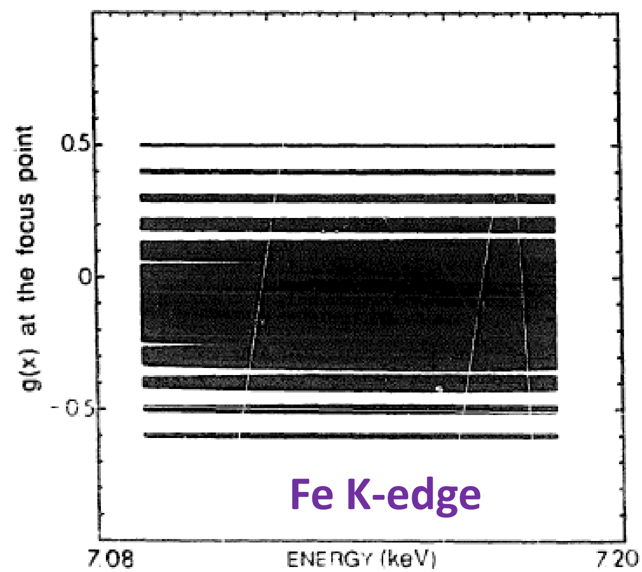








g. 12. Fe K-edge of metallic iron through a 20 μm slit. ...e of the image at the focus point is about 500 μm but, owing to the aberration-free optics, the full bandpass selected by the crystal goes throughout the sample.



Dispersive X-Ray Spectroscopy for Time-Resolved *In Situ* Observation of Electrochemical Inclusion of Metallic Clusters within a Conducting Polymer

G. Tourillon, E. Dartyge, A. Fontaine, and A. Jucha

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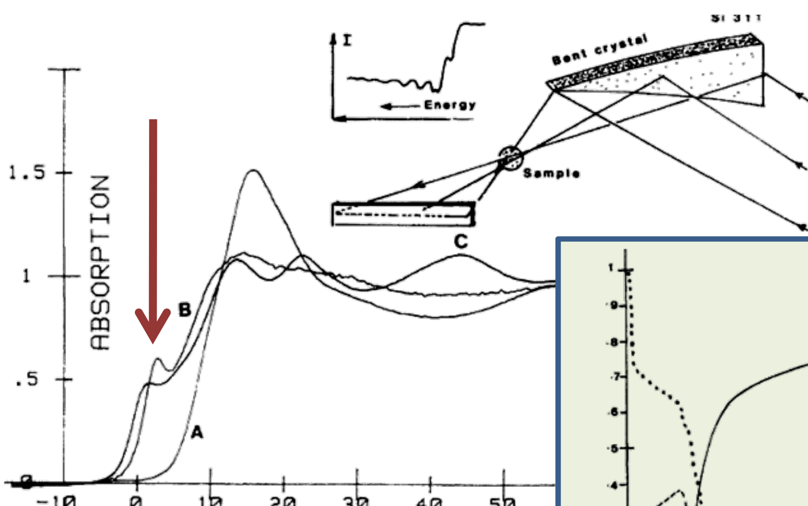
(Received 27 June 1985)

Electrochemically synthesized polythiophene is a very promising conducting polymer able to support tiny metallic particles which could be useful in various applications (e.g., conducting leads, catalysis, . . .). Time-resolved *in situ* investigation of the process of the inclusion of metallic aggregates has been achieved by dispersive x-ray absorption spectroscopy. The unique capability of this new structural tool comes from the association of the properties of synchrotron radiation with a photodiode array used as a position-sensitive detector.



A=Cu^{II}, B=Cu^{I}, C=metal

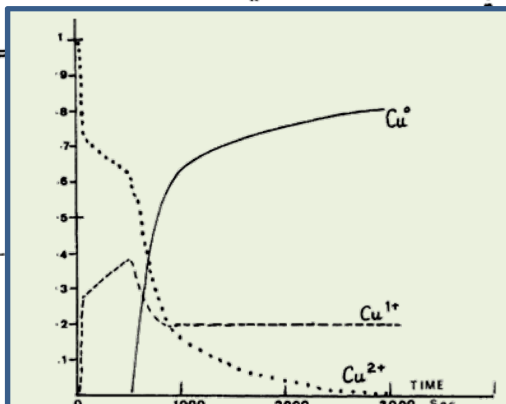
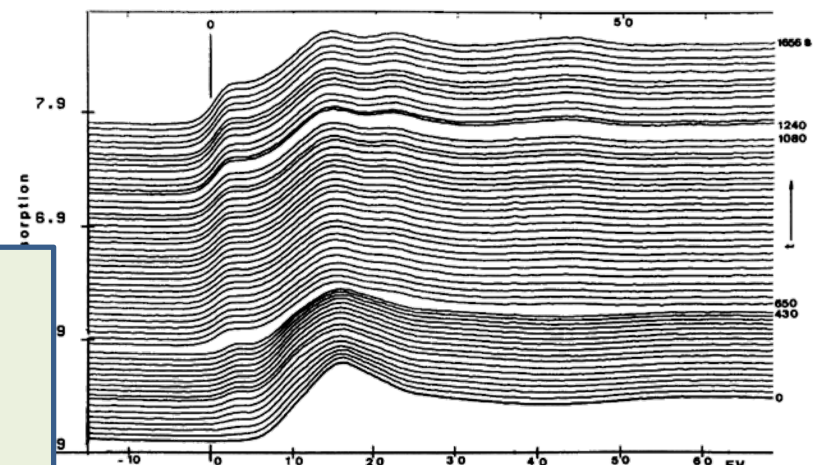


FIG. 3. Variations of the concentration of Cu^{2+}, Cu^{1+}, and Cu^0 inside the polymer vs the polarization time.



. 2. *In situ* measurements of the evolution of the Cu *K* edge when PMeT is cathodically polarized in an H_2O-$CuCl_2$ electrolytic medium.

VOLUME 55, NUMBER 4 PHYSICAL REVIEW LETTERS 22 JULY 1985

Band Gaps and Electronic Structure of Transition-Metal Compounds

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and

J. W. Allen
Xerox Palo Alto Research Center, Palo Alto, California 94304

George Sawatzky

January 1985)

Cuprates & High Tc superconductors

gaps and electronic structures of transition-metal
nted in which both the metallic sulfides and insu-
nanner.

Δ
$(d^n \rightarrow d^{n+1}\underline{L},$

U
$d_i^n, d_j^n \rightarrow d_i^{n+1}, d_j^{n-1}$

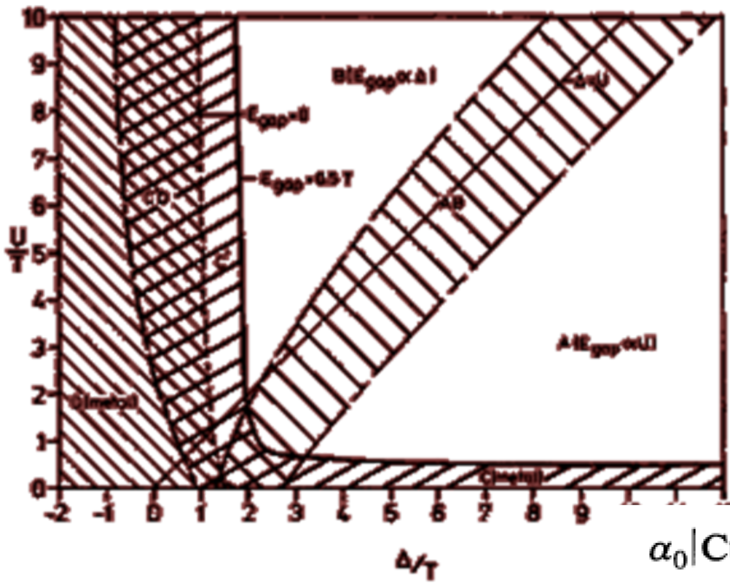
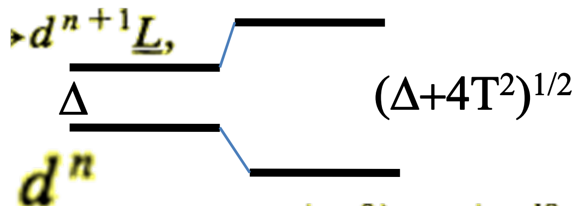


FIG. 3. A phase diagram exhibiting the various regions discussed in the text. The heavy solid line is the semiconductor-metal separation line.

the O 2p – Cu 3d hybridization energy (T),



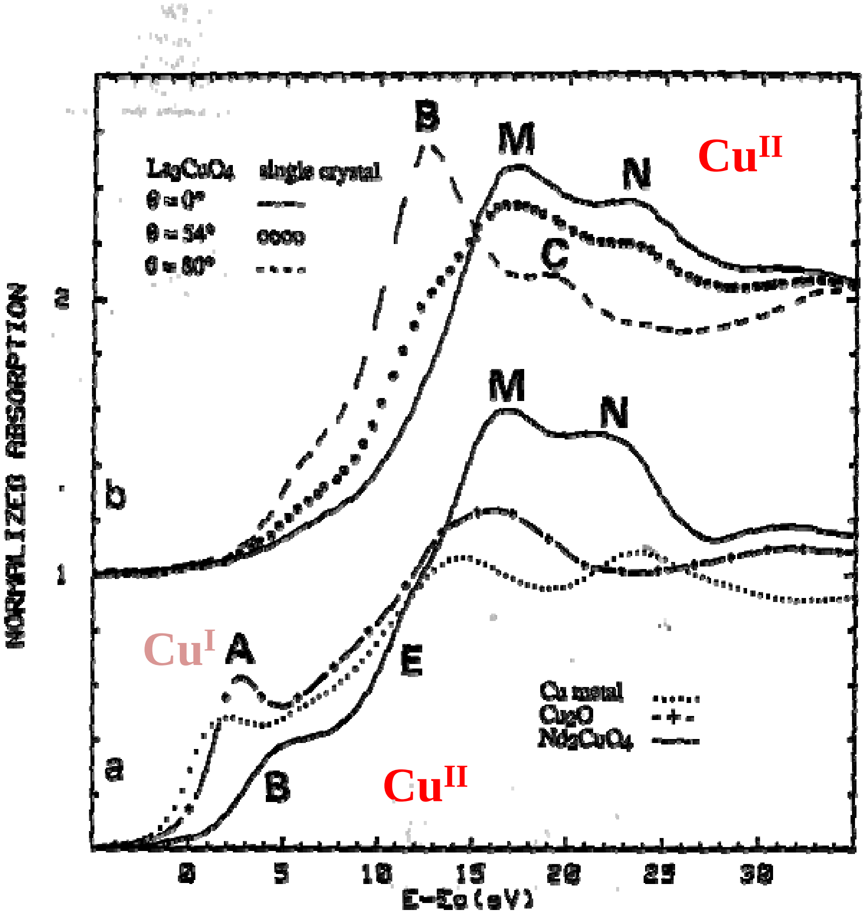
$\alpha_0|3d^9\rangle+\beta_0|3d^{10}\underline{L}\rangle$, with $\alpha_0^2+\beta_0^2=1$

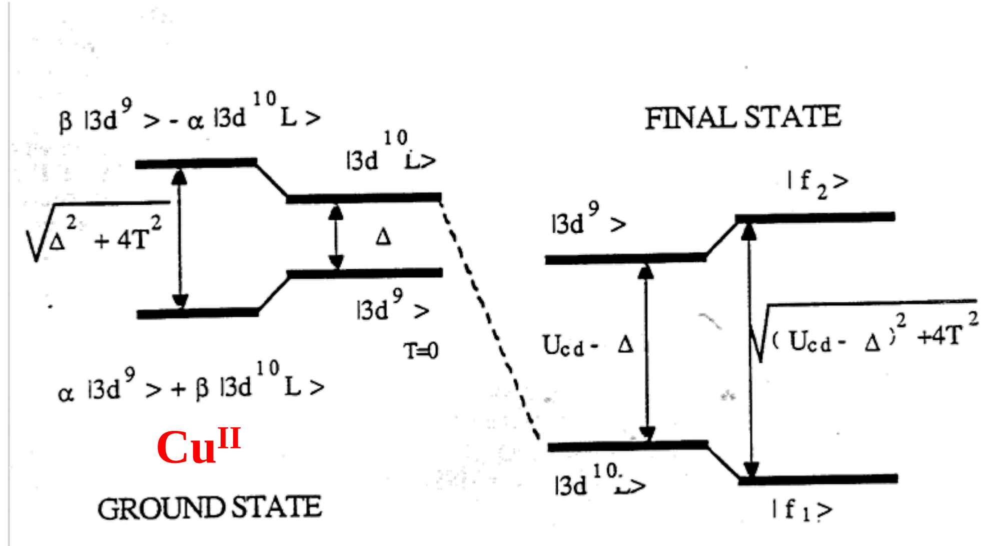
$\alpha_0|\mathrm{Cu}\ 1s^2\cdots 3d^9,\mathrm{O}\ 1s^2\cdots 2p^6\rangle+\beta_0|\mathrm{Cu}\ 1s^2\cdots 3d^{10},\mathrm{O}\ 1s^2\cdots 2p^5\rangle$

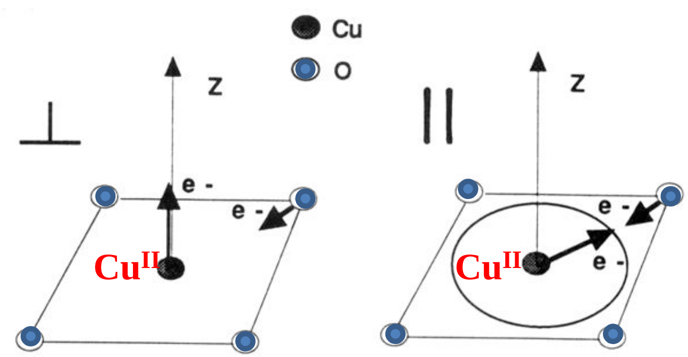
PHYSICAL REVIEW B VOLUME 45, NUMBER 14 1 APRIL 1992-II

Anisotropy of the core-hole relaxation in x-ray-absorption spectroscopy as probed in square planar cuprates

H. Tolentino,* M. Medarde, A. Fontaine, F. Baudelet, E. Dartyge, D. Guay, and G. Tourillon







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présentée
pour obtenir le

TITRE DE DOCTEUR EN SCIENCES

par

Hélio TOLENTINO

STRUCTURE ELECTRONIQUE DES SUPRACONDUCTEURS

A HAUTE TEMPERATURE CRITIQUE

PAR SPECTROSCOPIE D'ABSORPTION DE NIVEAUX DE CŒUR

soutenue le 14 Novembre 1990 devant la commission d'examen

M.	J. P. BURGER	Président
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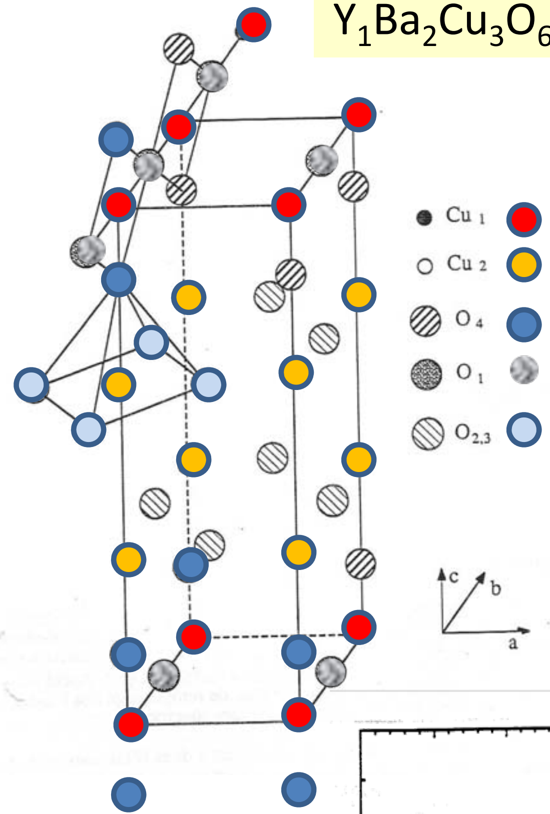
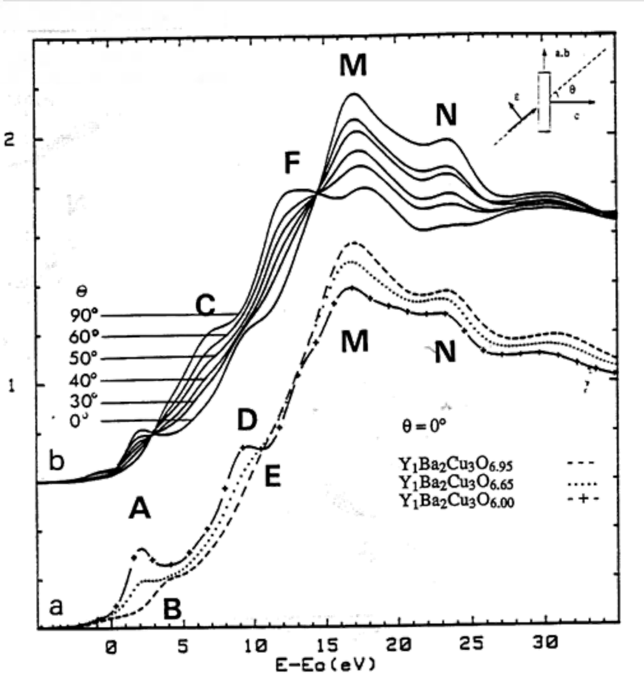
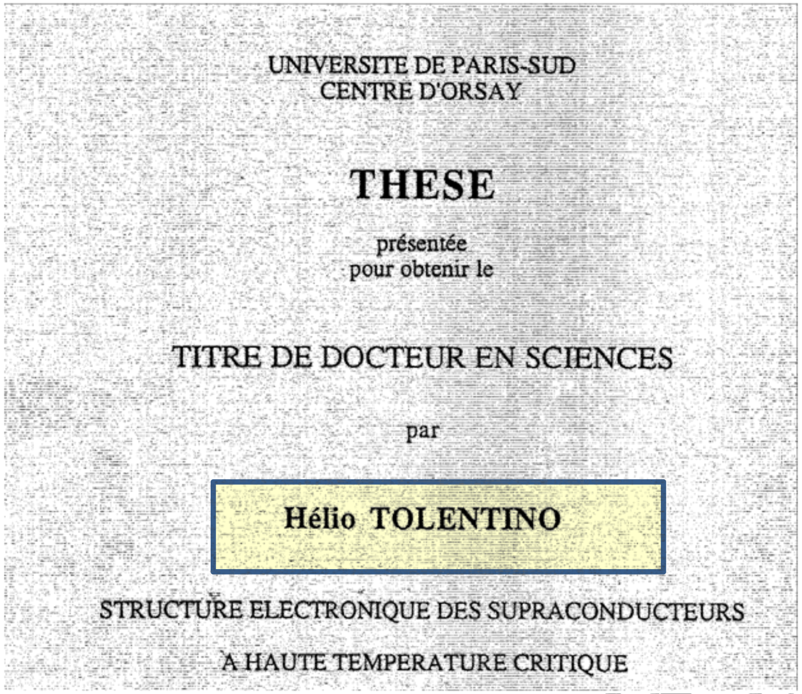
M.	B. RAVEAU	

$Y_1Ba_2Cu_3O_6$ $Y_1Ba_2Cu_3O_7$



Cu^I or Cu^{II}
Cu^{II}

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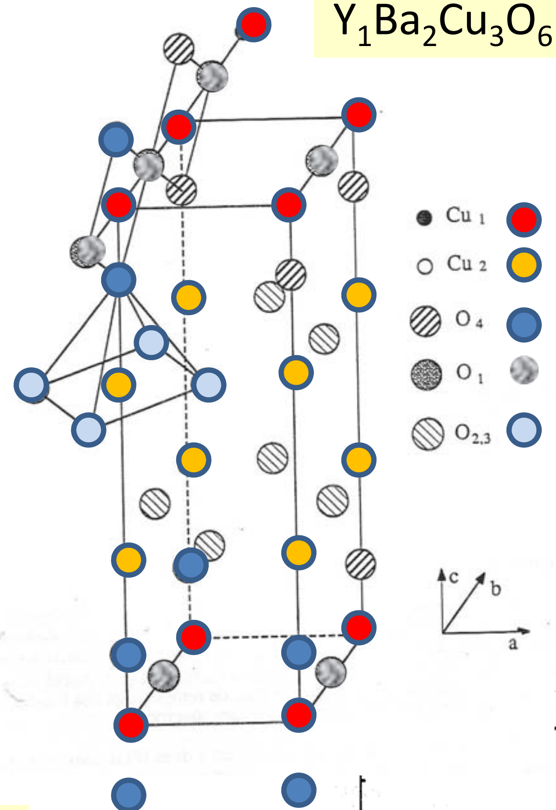
par

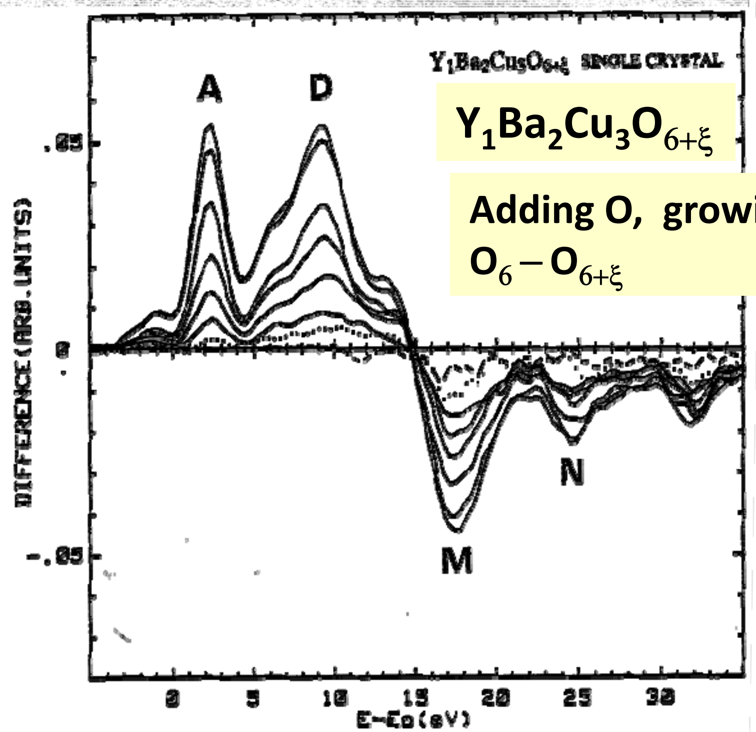
Hélio TOLENTINO

STRUCTURE ELECTRONIQUE DES SUPRACONDUCTEURS
A HAUTE TEMPERATURE CRITIQUE

$Y_1Ba_2Cu_3O_6$ $Y_1Ba_2Cu_3O_7$

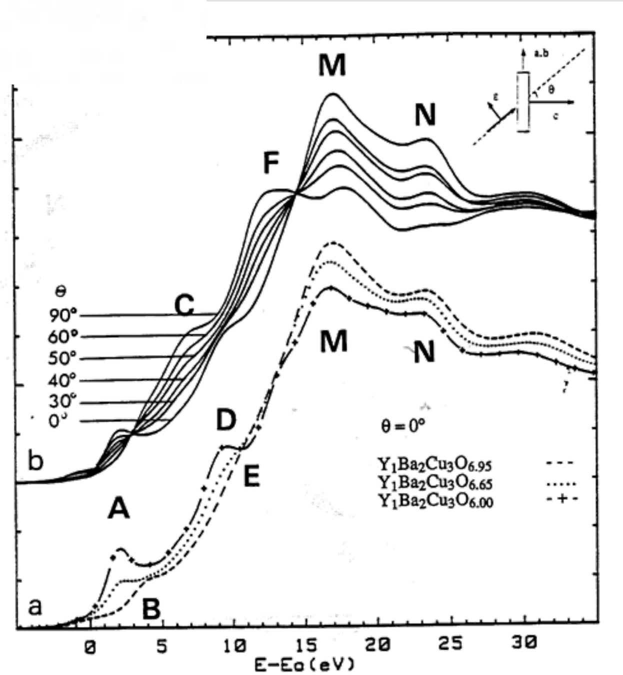


Cu^{I} or Cu^{II}
Cu^{II}

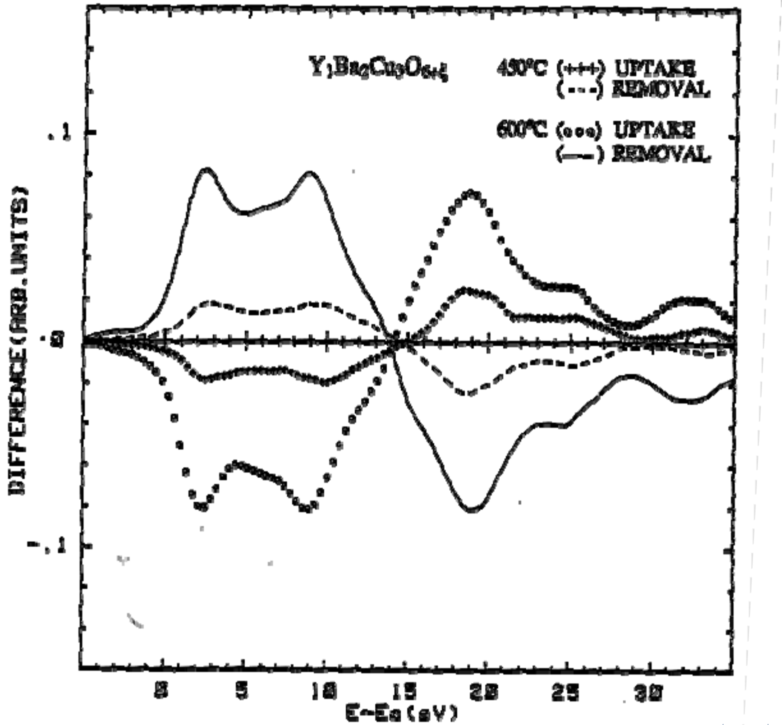


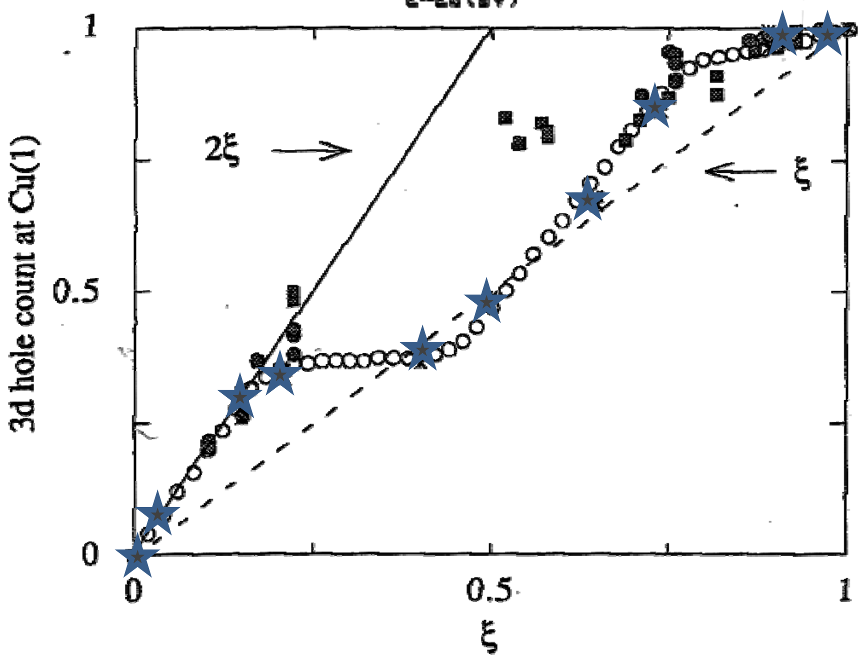
$Y_1Ba_2Cu_3O_{6+\xi}$

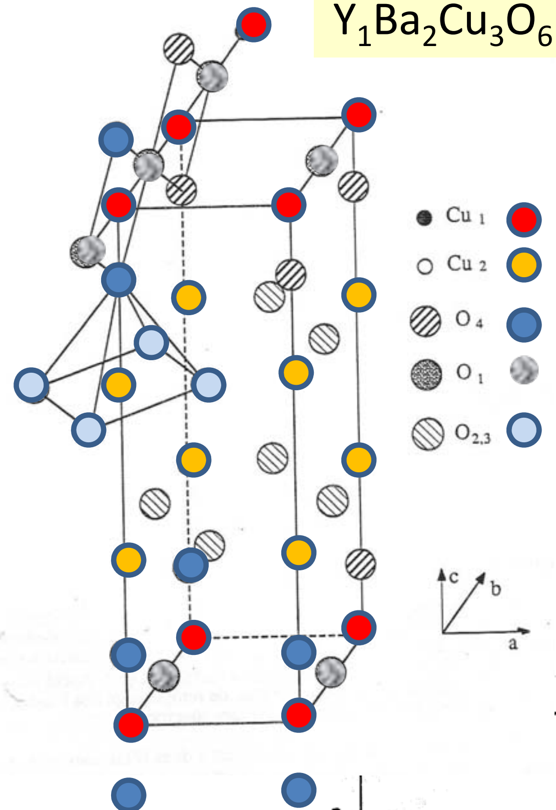
Adding O, growing ξ
$O_6 - O_{6+\xi}$



$Y_1Ba_2Cu_3O_6$ $Y_1Ba_2Cu_3O_7$

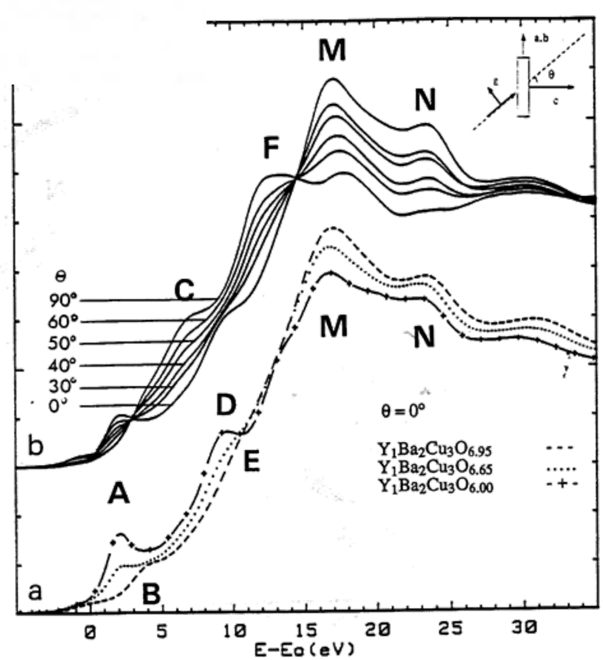


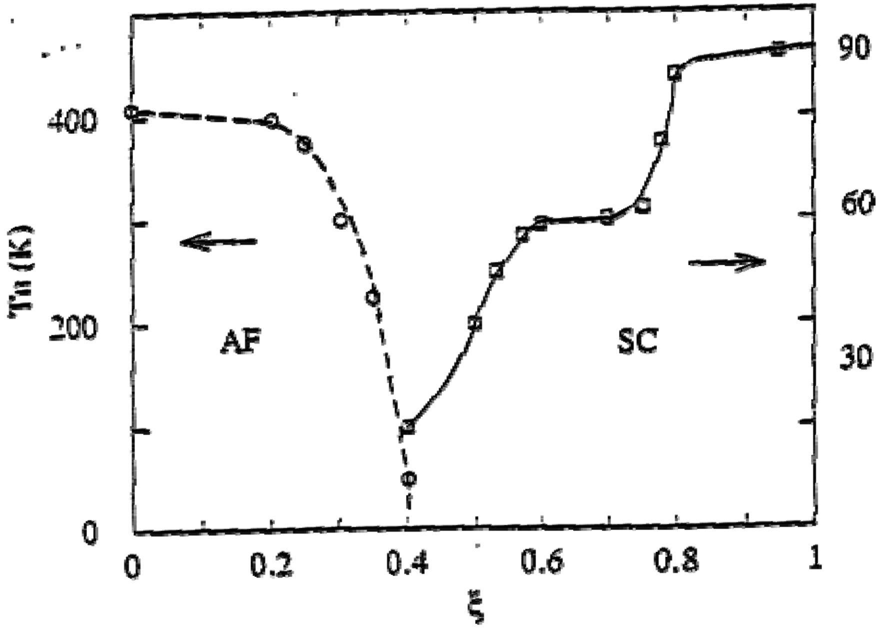


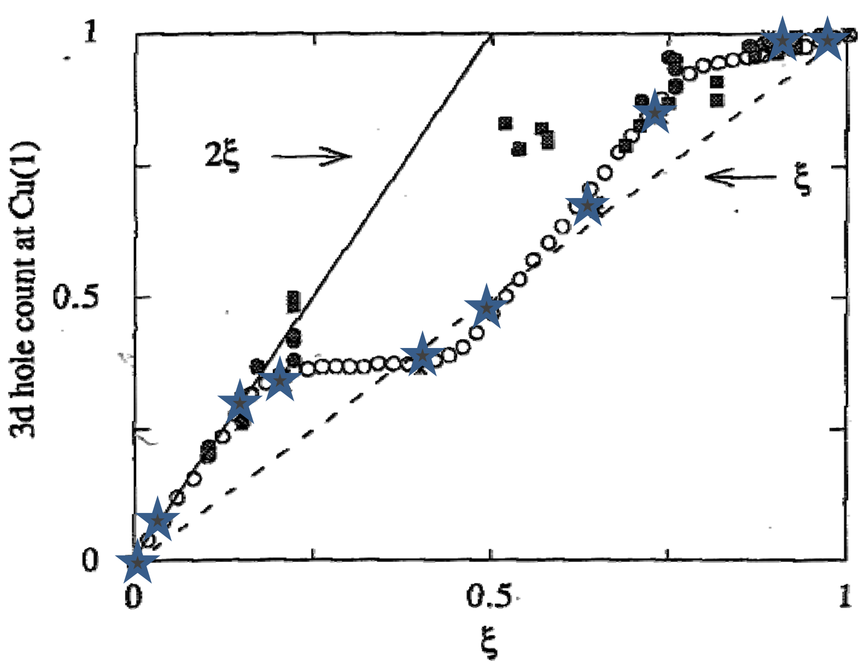


Cu^{I} or Cu^{II}

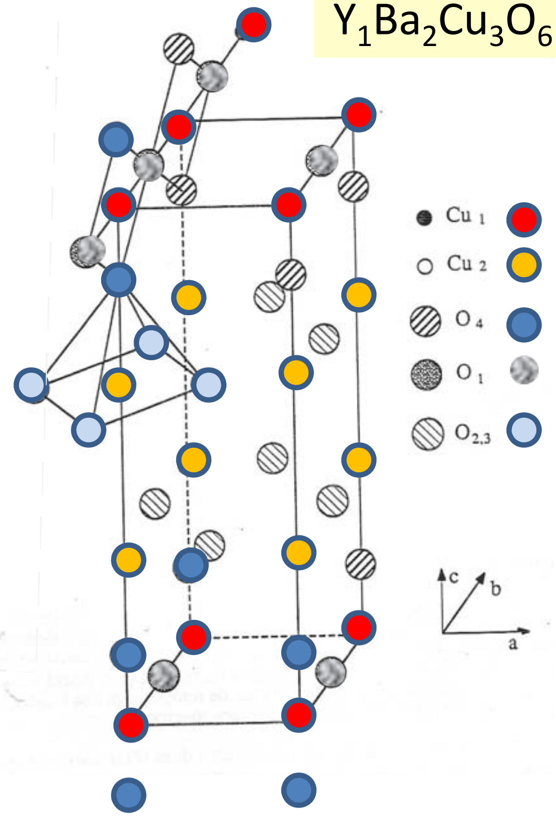
Cu^{II}







$Y_1Ba_2Cu_3O_6$ $Y_1Ba_2Cu_3O_7$



Cu^{I} or Cu^{II}

Cu^{II}

Hélio Tolentino's thesis

PHYSICAL REVIEW B VOLUME 39, NUMBER 5 15 FEBRUARY 1989-I

X-ray absorption spectroscopy on solid krypton up to 20 GPa

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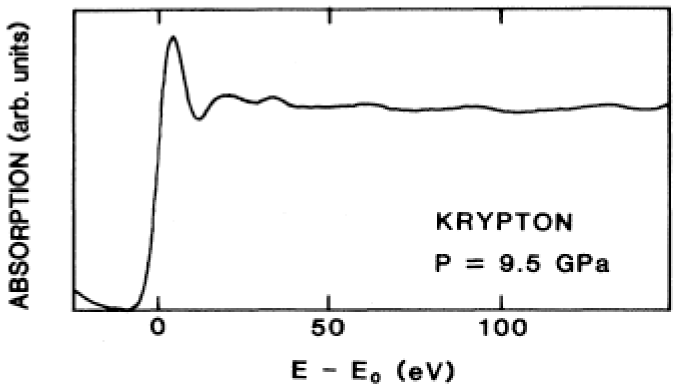
(Received 27 July 1988)

J.P.Itié, A.Polian, A.San Miguel



$$\chi(k) = -\sum_j \frac{N_j}{kR_j^2} |f_j(k,\pi)| \sin[2\mathbf{k}\cdot\mathbf{R}_j + \Psi_j(k)] \times e^{-2\sigma_j^2 k^2} e^{-2R_j/\lambda_j(k)}, \quad (1$$

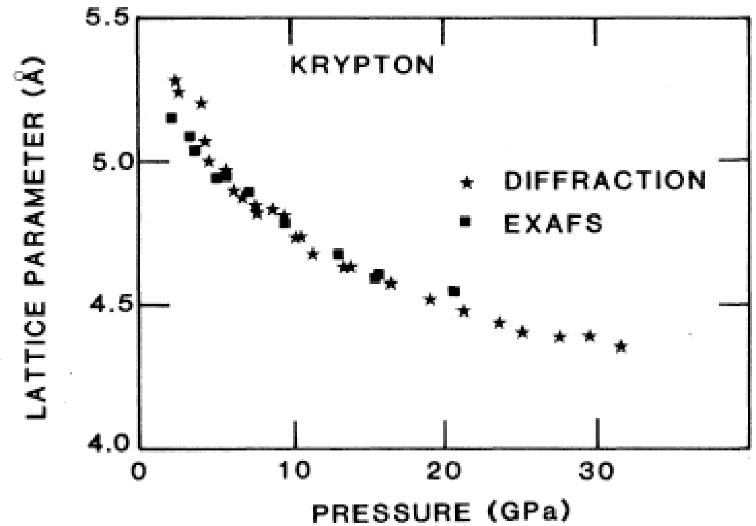


FIG. 6. Comparison of the pressure dependence of the lattice parameter determined by x-ray diffraction (squares) and EXAFS (stars).

PHYSICAL REVIEW B VOLUME 39, NUMBER 5 15 FEBRUARY 1989-I

X-ray absorption spectroscopy on solid krypton up to 20 GPa

A. Polian and J. P. Itie
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E. Dartyge, A. Fontaine, and G. Tourillon
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(Received 27 July 1988)

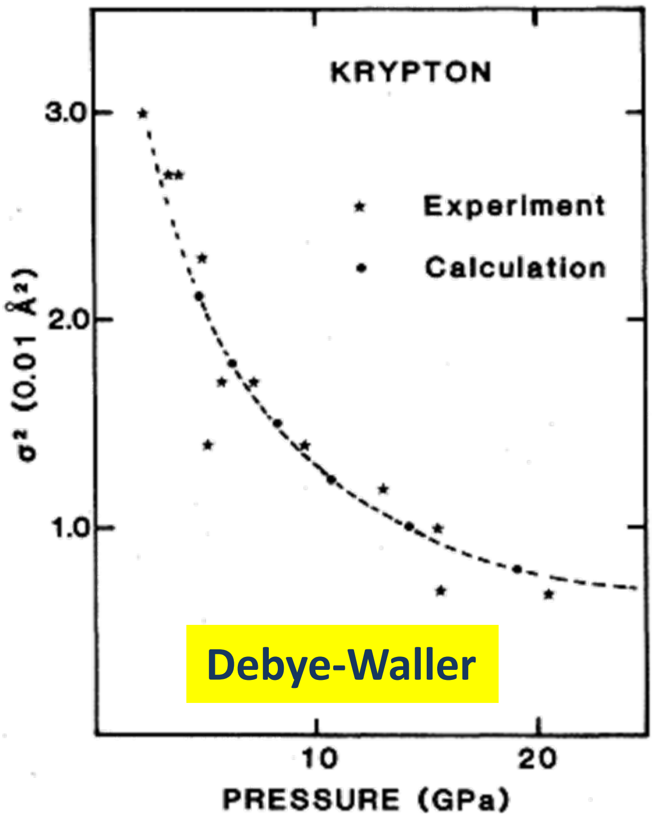

FIG. 7. Experimental (stars) and calculated (points) Debye-Waller factor. Reference for the experiments is taken at $P = 15.7$ GPa. All the experimental points are then shifted by a constant value (see text).

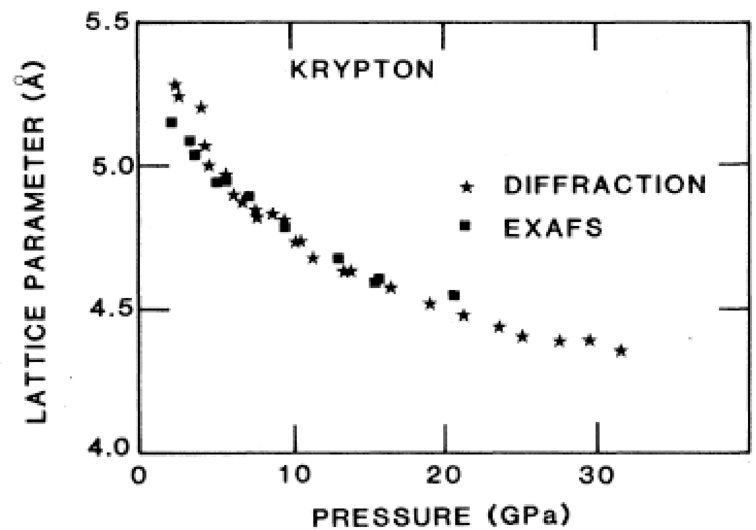

FIG. 6. Comparison of the pressure dependence of the lattice parameter determined by x-ray diffraction (squares) and EXAFS (stars).

Pressure-Induced Coordination Changes in Crystalline and Vitreous GeO_2

J. P. Itie,[1] A. Polian,[1] G. Calas,[2] J. Petiau,[2] A. Fontaine,[3] and H. Tolentino[3]

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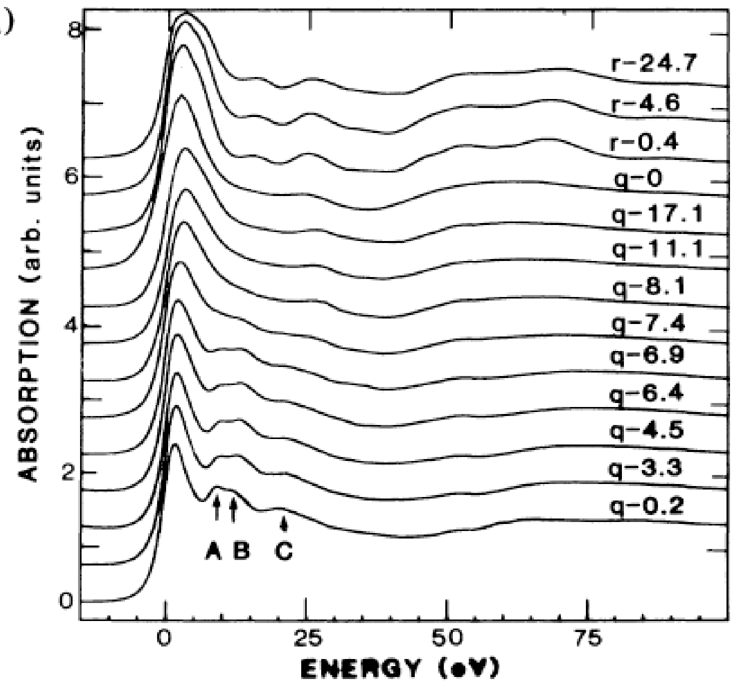
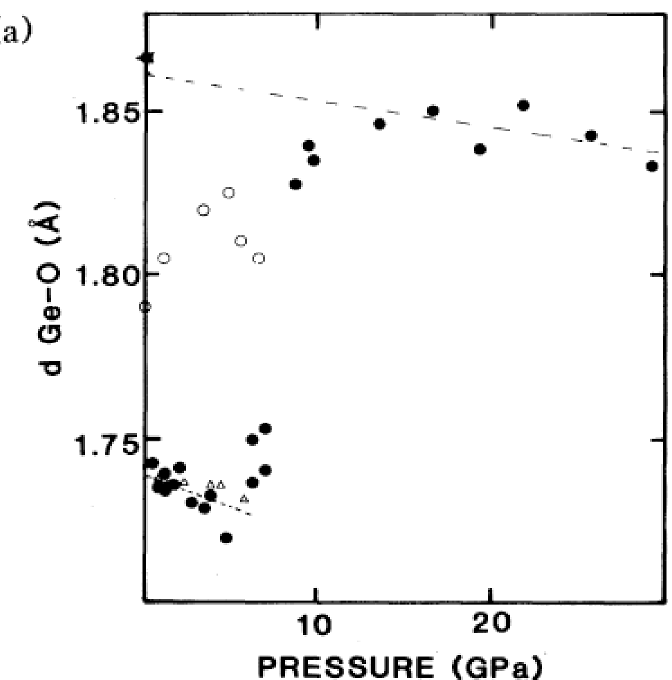
(Received 21 February 1989)

In situ high-pressure x-ray-absorption spectra have been performed on amorphous and crystalline GeO_2 using a diamond-anvil cell adapted to an energy-dispersive spectrometer. The coordination of Ge changes from fourfold to sixfold at pressures between 7 and 9 GPa. The progressive evolution of the measured Ge-O distances as well as the modification in the x-ray-absorption near-edge structure indicate two different sites rather than a progressive site modification. The phase transition observed in the

(a)



(a)



(b)

Pressure-Induced Coordination Changes in Crystalline and Vitreous GeO_2

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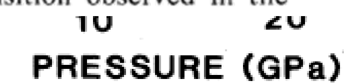
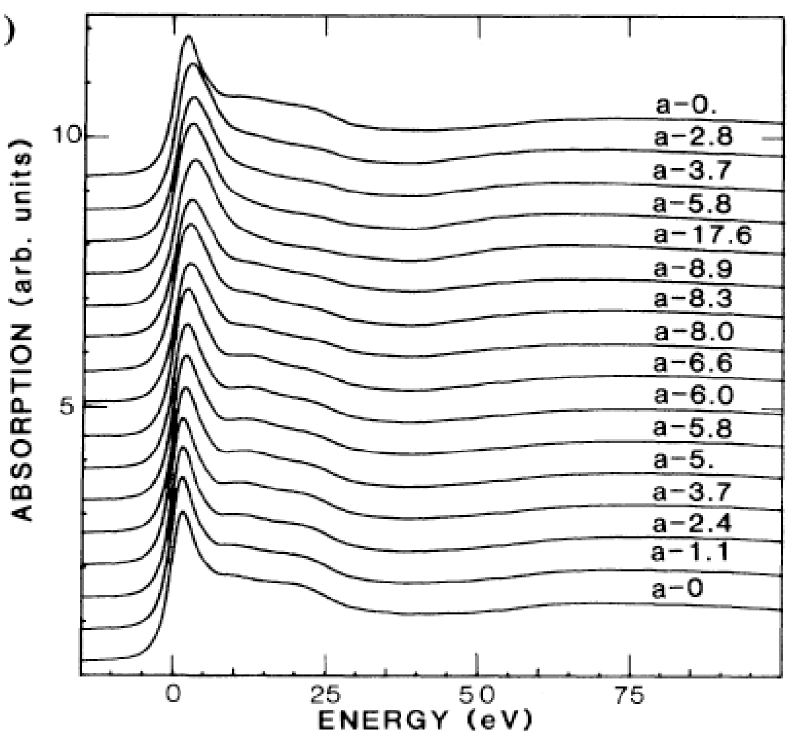
(Received 21 February 1989)

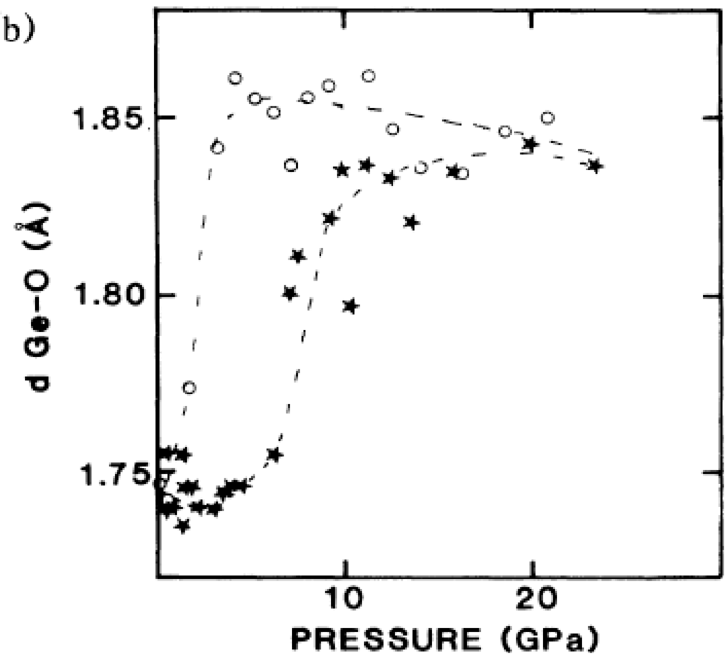
In situ high-pressure x-ray-absorption spectra have been performed on amorphous and crystalline GeO_2 using a diamond-anvil cell adapted to an energy-dispersive spectrometer. The coordination of Ge changes from fourfold to sixfold at pressures between 7 and 9 GPa. The progressive evolution of the measured Ge-O distances as well as the modification in the x-ray-absorption near-edge structure indicate two different sites rather than a progressive site modification. The phase transition observed in the

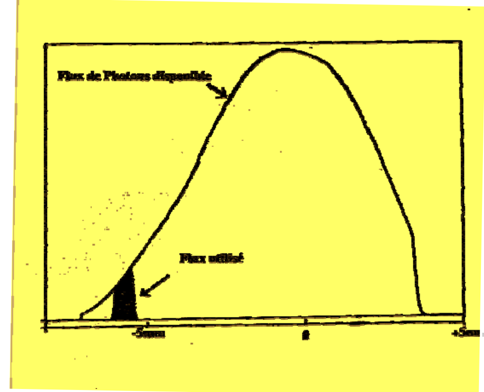


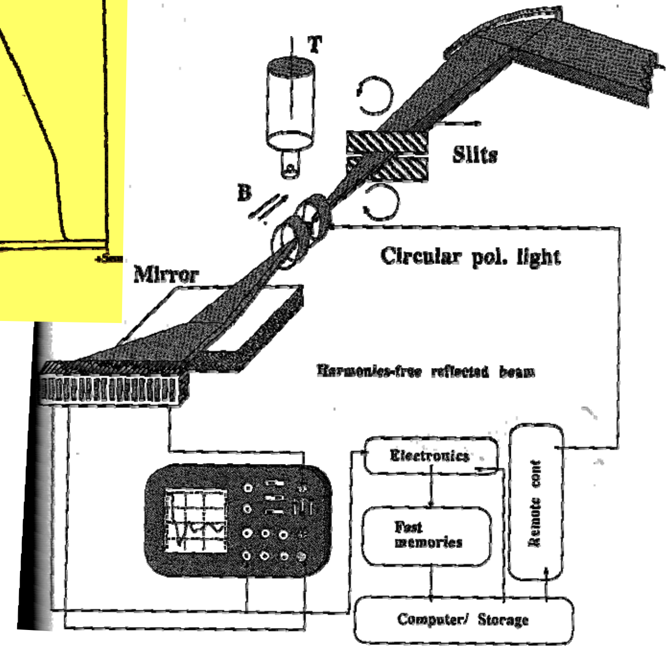
(b)



(b)







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T.Thole, G.Van der Laan, G.Sawatzky ,
J.Goedkoop '85,'86
&
G.Schütz '87

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1988

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Energy Dispersive X-ray Absorption Spectroscopy: the XMCD start at LURE

EUROPHYSICS LETTERS 15 December 1990
Europhys. Lett., 13 (8), pp. 751-757 (1990)

François Baudelet

Magnetic Properties of $REFe_2$ (RE: Ce, Gd, Lu) Compounds Studied by Magnetic X-Ray Dichroism.

F. BAUDELET (*), C. BROUDER (**), E. DARTYGE (*), A. FONTAINE (*)
J. P. KAPPLER (***) and G. KRILL (**)

(*) *LURE, LP CNRS 008, Université de Paris-Sud - 91405 Orsay, France*
(**) *Laboratoire de Physique des Solides, UA CNRS 155, Université de N*
BP 239, 54506 Vandoeuvre-les-Nancy, France
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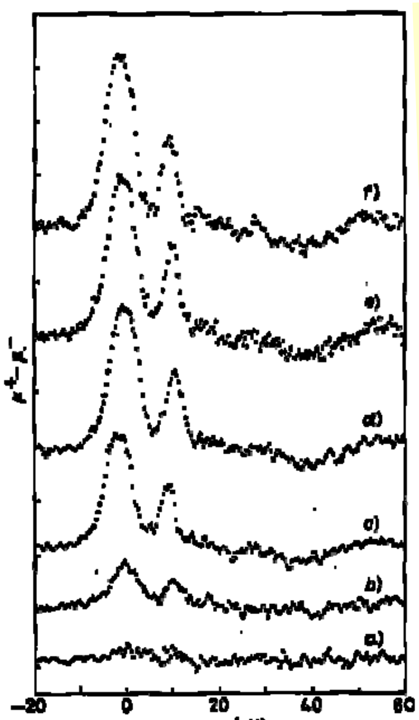
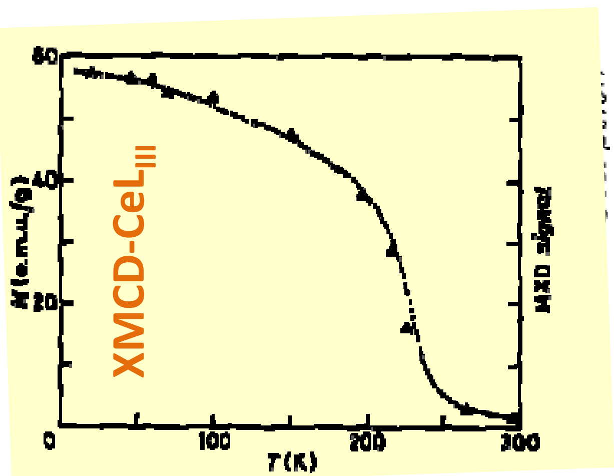
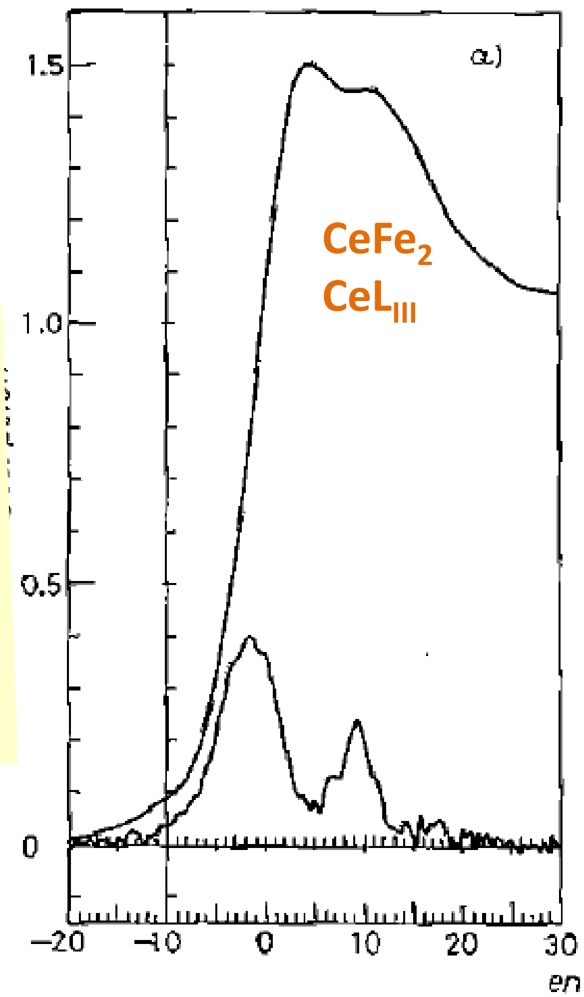
67070 Strasbourg, France







Magnetic circular x-ray dichroism measurements of Fe-Co alloys and Fe/Co multilayers

S. Pizzini, A. Fontaine, E. Dartyge, and C. Giorgetti

Laboratoire pour l'Utilisation du Rayonnement Electromagnétique, Bâtiment 209D, Centre Universitaire Paris-Sud, 91405 Orsay, France

et al. PRB'94,50

Stefania Pizzini

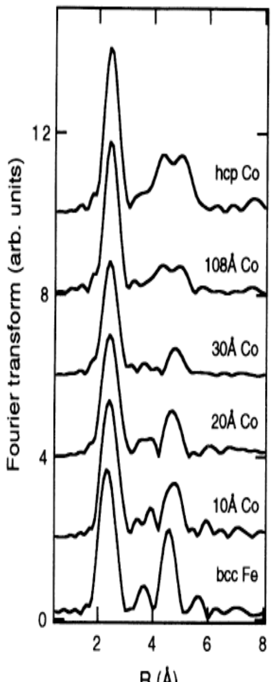


FIG. 2. The Fourier transforms (FT) of the in-plane Co K edge EXAFS spectra of the multilayers $Fe_{21\,Å}Co_{10\,Å}$, $Fe_{17\,Å}Co_{20\,Å}$, $Fe_{21\,Å}Co_{30\,Å}$, and $Fe_{21\,Å}Co_{108\,Å}$ (3→12 $Å^{-1}$) ar compared with the FT of bulk Fe at the Fe K edge and of hc Co at the Co K edge. For clarity, the spectra have been shifte with respect to bulk Fe.

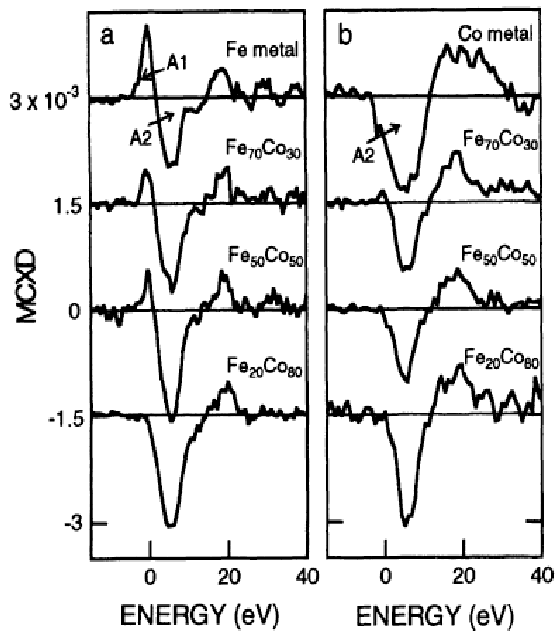


FIG. 3. Fe *K* and Co *K* near-edge MCXD spectra for bcc Fe and hcp Co and for the $Fe_{70}Co_{30}$, $Fe_{50}Co_{50}$ and $Fe_{20}Co_{80}$ alloys. The energy axis is scaled to be absorption edge positions and the MCXD signals are normalized to the absorption edge step height. (a) Fe *K* edge; (b) Co *K* edge. For convenience, the spectra have been shifted with respect to bcc Fe in (a) and hcp Co in (b).

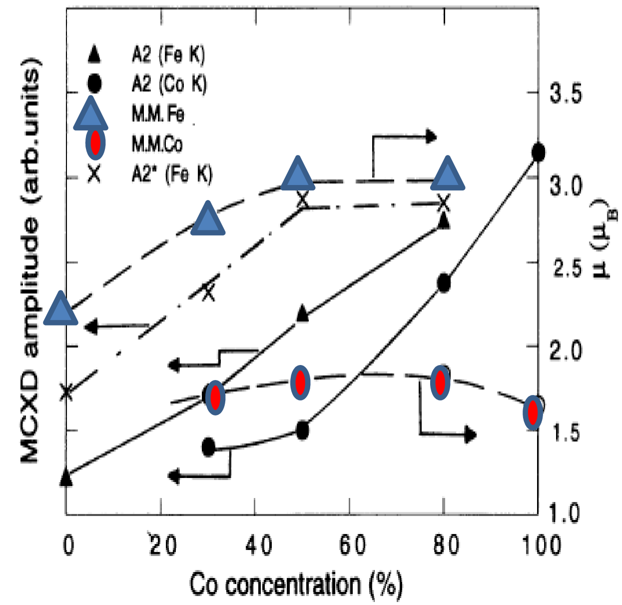


FIG. 6. The integrated intensities of the negative peaks *A*2 of the MCXD spectra measured for bcc Fe, hcp Co, and Fe-Co alloys (Table II) are compared with local magnetic moments (M.M.) on the Fe and Co sites. *A*2 are the integrated intensities, *A*2* the maximum amplitudes. The value reported for pure bcc Co is the average signal obtained for the bcc Co films in the Fe/Co multilayers. The dotted lines are guides for the eye.

Magnetic circular x-ray dichroism measurements of Fe-Co alloys and Fe/Co multilayers

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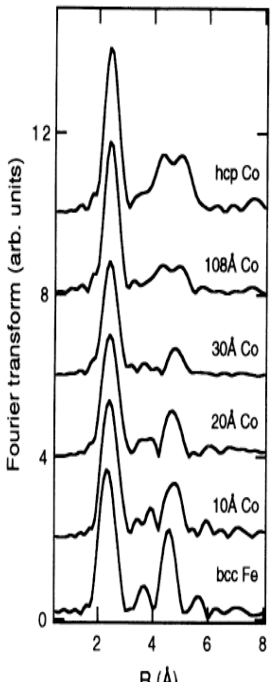

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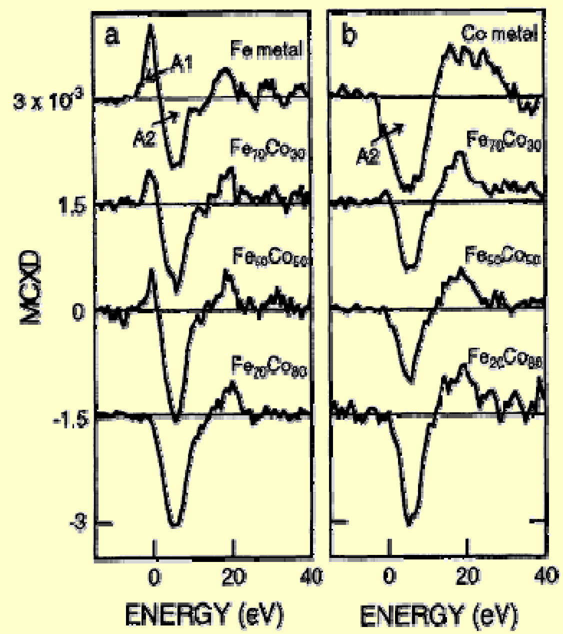

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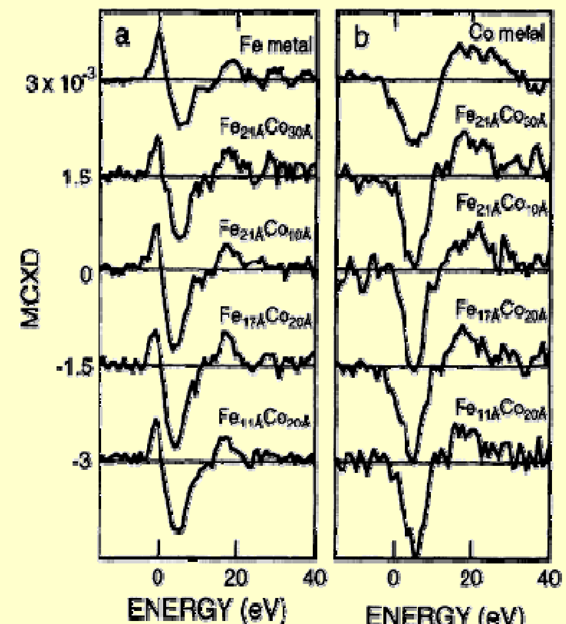

FIG. 4. Near-edge MCXD spectra for Fe/Co multilayer The energy axis is scaled to the absorption edge positions, ar the MCXD signals are normalized to the absorption edge ste height. (a) Fe *K*-edge spectra compared and shifted with respe to Fe metal. (b) Co *K*-edge spectra compared and shifted wi respect to hcp Co.

Evidence for the Spin Polarization of Copper in Co/Cu and Fe/Cu Multilayers

Stefania Pizzini,* Alain Fontaine, Christine Giorgetti, and Elisabeth Dartyge
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(Received 19 July 1994)

Magnetic circular x-ray dichroism on Co/Cu and Fe/Cu multilayers at the *K* edge of copper shows (i) that the *p* band of copper is significantly spin polarized by the adjacent Co or Fe atoms, (ii) that the spin polarization of the copper layers strongly depends on the adjacent magnetic layer, and (iii) that the magnetic polarization is not restricted to the interface layer, i.e., it departs from a simple $1/t_{Cu}$ dependence.

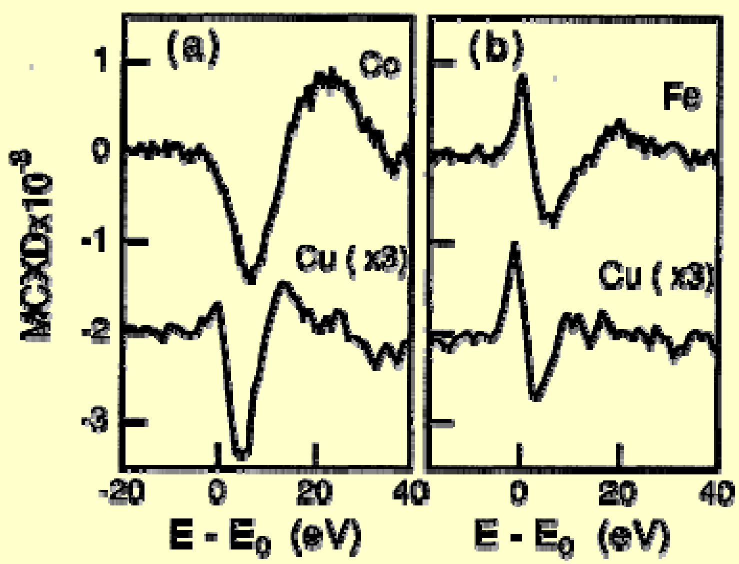

FIG. 2. (a) Cu *K*-edge and Co *K*-edge MCXD spectra of the $Co_{12 Å}Cu_{8 Å}$ multilayer; (b) Cu *K*-edge and Fe *K*-edge MCXD spectra of the $Fe_{12 Å}Cu_{8 Å}$ multilayer. The Cu *K*-edge signals have been multiplied by 3.

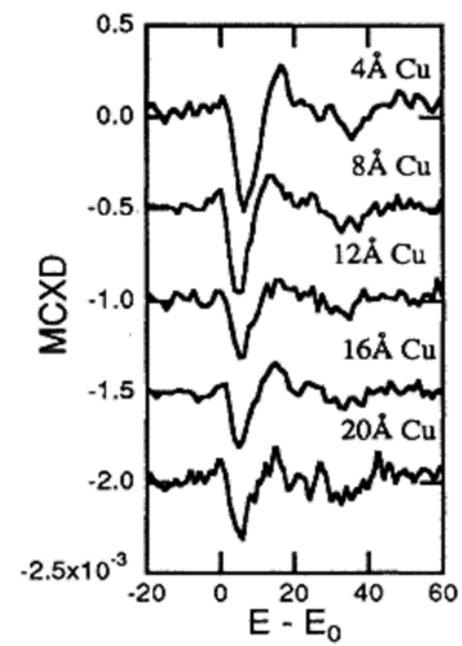

FIG. 4. Cu *K*-edge MCXD signal for a series of $Co_{12 Å}Cu_x$ (x = 4, 8, 12, 16, and 20 Å) multilayers. The amplitudes of the signals are summarized in Fig. 3.

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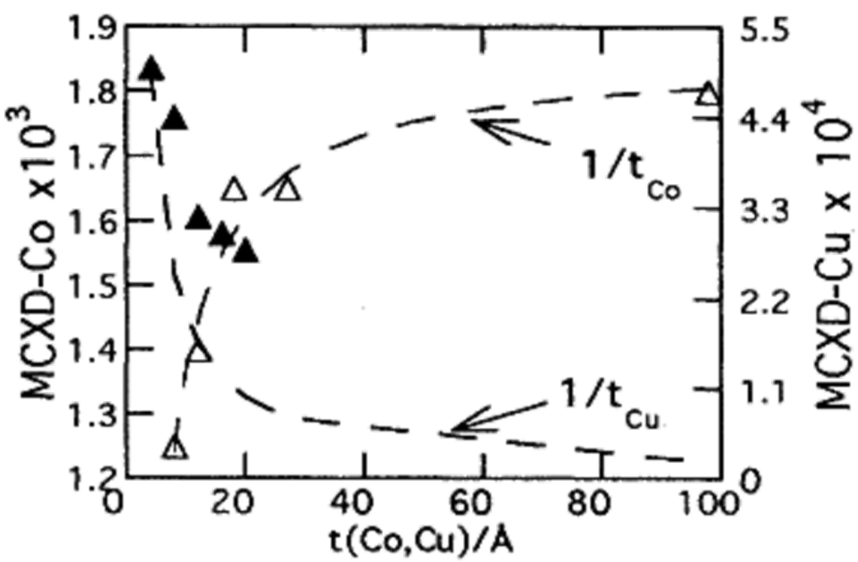
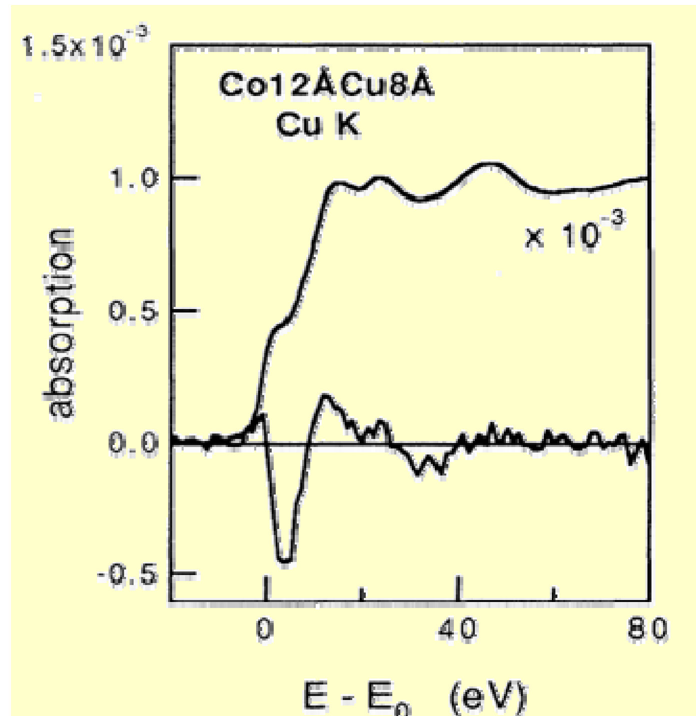
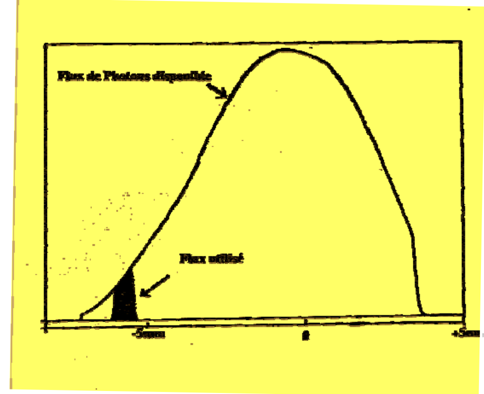
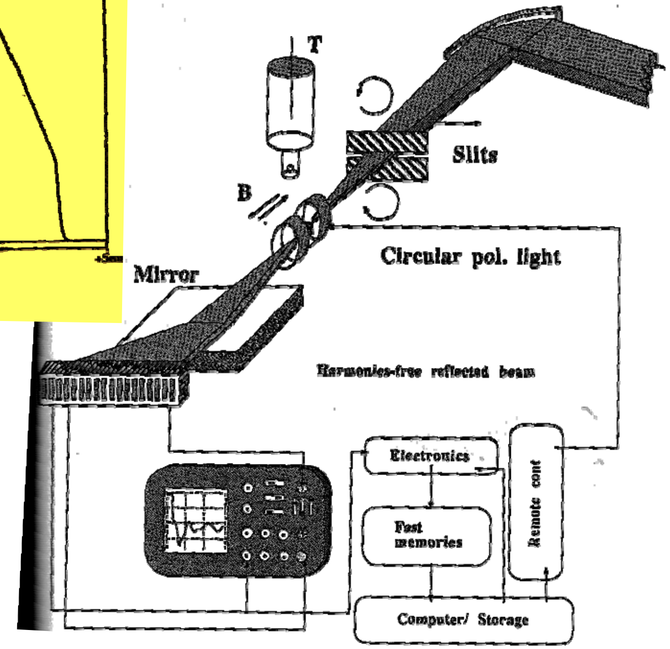


FIG. 3. The thickness dependence of the amplitude of the MCXD signal in Co/Cu multilayers: Co *K* and Cu *K* edges. The amplitude of the Co *K*-edge MCXD signal can be fitted to an $A - B/t$ function; the amplitude of the Cu *K*-edge MCXD signal departs from a $1/t$ dependence.







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Energy Dispersive X-ray Absorption Spectroscopy: the XMCD before ESRF: tunability of the photon helicity thanks to QWP

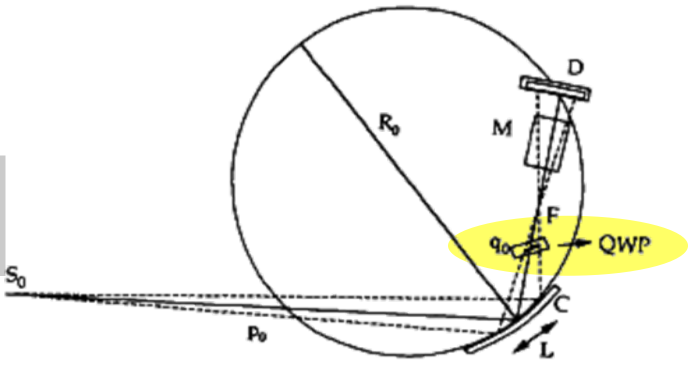
QWP: José Goulon, Cécile Malgrange, Carlos Giles

J. Appl. Cryst. (1994). **27**, 232–240

Energy-Dispersive Phase Plate for Magnetic Circular Dichroism Experiments in the X-ray Range

By Carlos Giles, Cécile Malgrange,* José Goulon, François de Bergevin† and Christian Vettier
ESRF–European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble CEDEX, France

and Elizabeth Dartyge, Alain Fontaine, Christine Giorgetti and Stefania Pizzini
LURE, CNRS–CEA–MEN, associé à l'Université de Paris-Sud (Orsay), Bâtiment 209d, F-91405 Orsay CEDEX, France

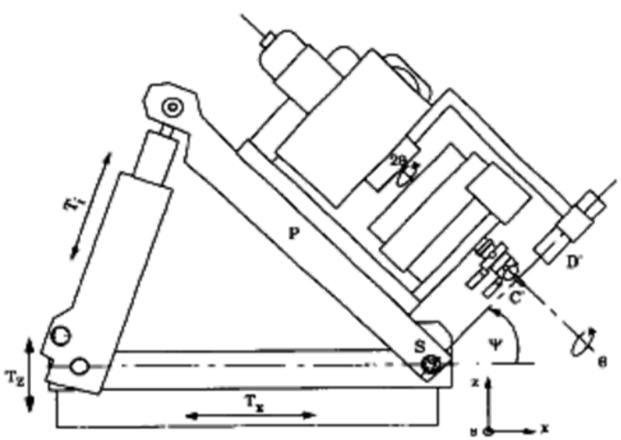


(a)

$$\varphi = 2\pi k(n_\sigma - n_\pi)t = 2\pi(X_0'^{\sigma} - X_0'^{\pi})t,$$

$$n_\sigma - n_\pi = -\{[\chi_h \chi_{\bar{h}}]/4(\Delta\theta - \Delta\theta_0)\} \sin 2\theta \times\{1 + \{[\chi_h \chi_{\bar{h}}]|\gamma|/4(\Delta\theta - \Delta\theta_0)^2\} \times(1 + 2 \cot^2 2\theta) + \ldots).$$

$$\varphi = -\frac{\pi}{2}\frac{r_e^2 \lambda^3 \mathrm{Re}[F_h F_{\bar{h}}](\sin 2\theta)t}{[\pi V]^2[\Delta\theta - \Delta\theta_0]}.$$



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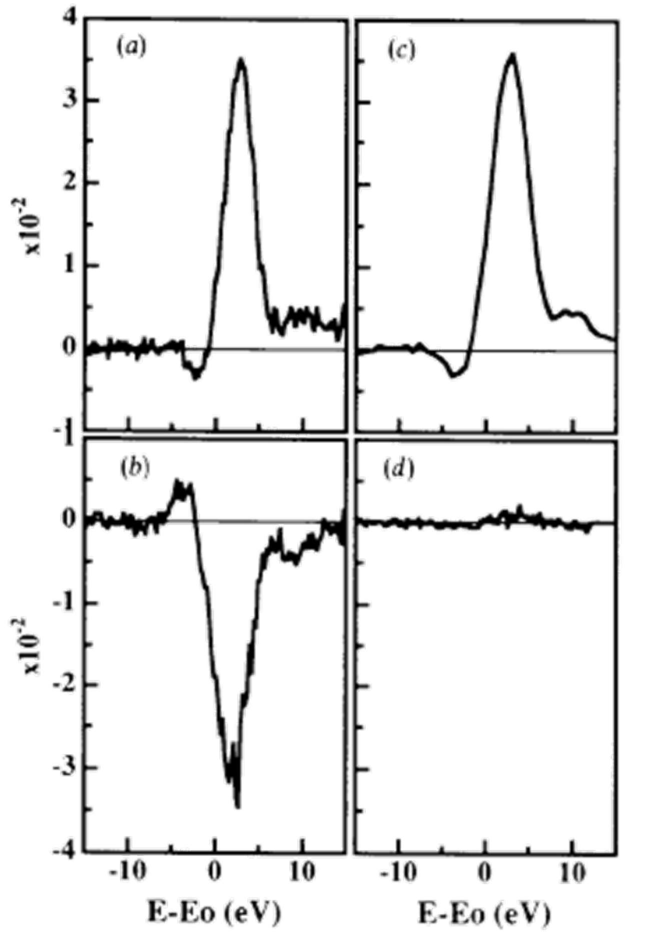

g. 5. CMXD spectra of the Laves-phase $GdFe_2$ at the Gd L_{III}

This work, thus, opens attractive new perspectives for the international ESRF BL # 8 project, which is concerned with the construction of a high-brilliance energy-dispersive spectrometer exploiting a standard planar undulator as a source (Hagelstein, Fontaine & Goulon, 1992).

The diamond crystal used in these experiments was borrowed from Professor A. R. Lang (University of Bristol) who is thanked for his help. This work was initiated and supported financially by the ESRF. One

Energy Dispersive X-ray Absorption Spectroscopy: Scientific Opportunities and Technical Challenges

2009

2007

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1985

Exploring magnetism within extreme magnetic fields

XMCD with very high magnetic fields using an energy-dispersive X-ray absorption spectrometer ***at the ESRF's energy-dispersive XAS beamline ID24.*** *07-10-2008 16:03*

30 T & 10 K : Ca_2FeReO_6

350 microseconds,

Peter van der Linden setting up the ESRF pulsed magnetic field device at ID24.

M. Sikora
University of Science and Technology
Krakow, Poland
Feb 3rd: 12H00

XAS and XMCD under high magnetic field and low temperature on the energy-dispersive beamline of the ESRF, **O. Mathon (a), P. van der Linden (a), T. Neisius (b), M. Sikora (a), J.M. Michalik (c), C. Ponchut (a), J.M. De Teresa (d) and S. Pascarelli (a),** *J. Synchrotron Rad.* **14**, 409 (2007).

Exploring magnetism within extreme magnetic fields

XMCD with very high magnetic fields using an energy-dispersive X-ray absorption spectrometer ***at the ESRF's energy-dispersive XAS beamline ID24.*** *07-10-2008 16:03*

30 T & 10 K : Ca_2FeReO_6
350 microseconds,

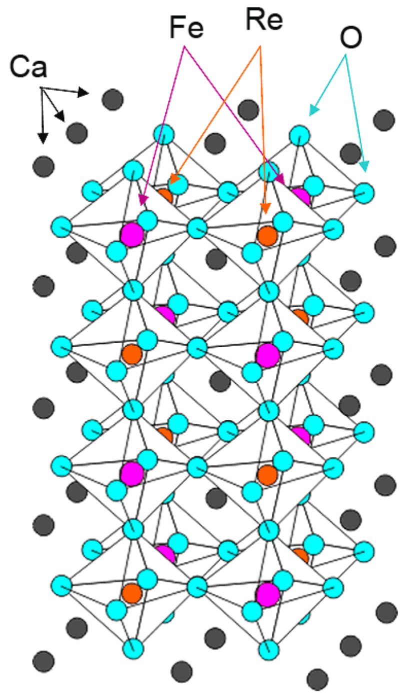
QWP Si

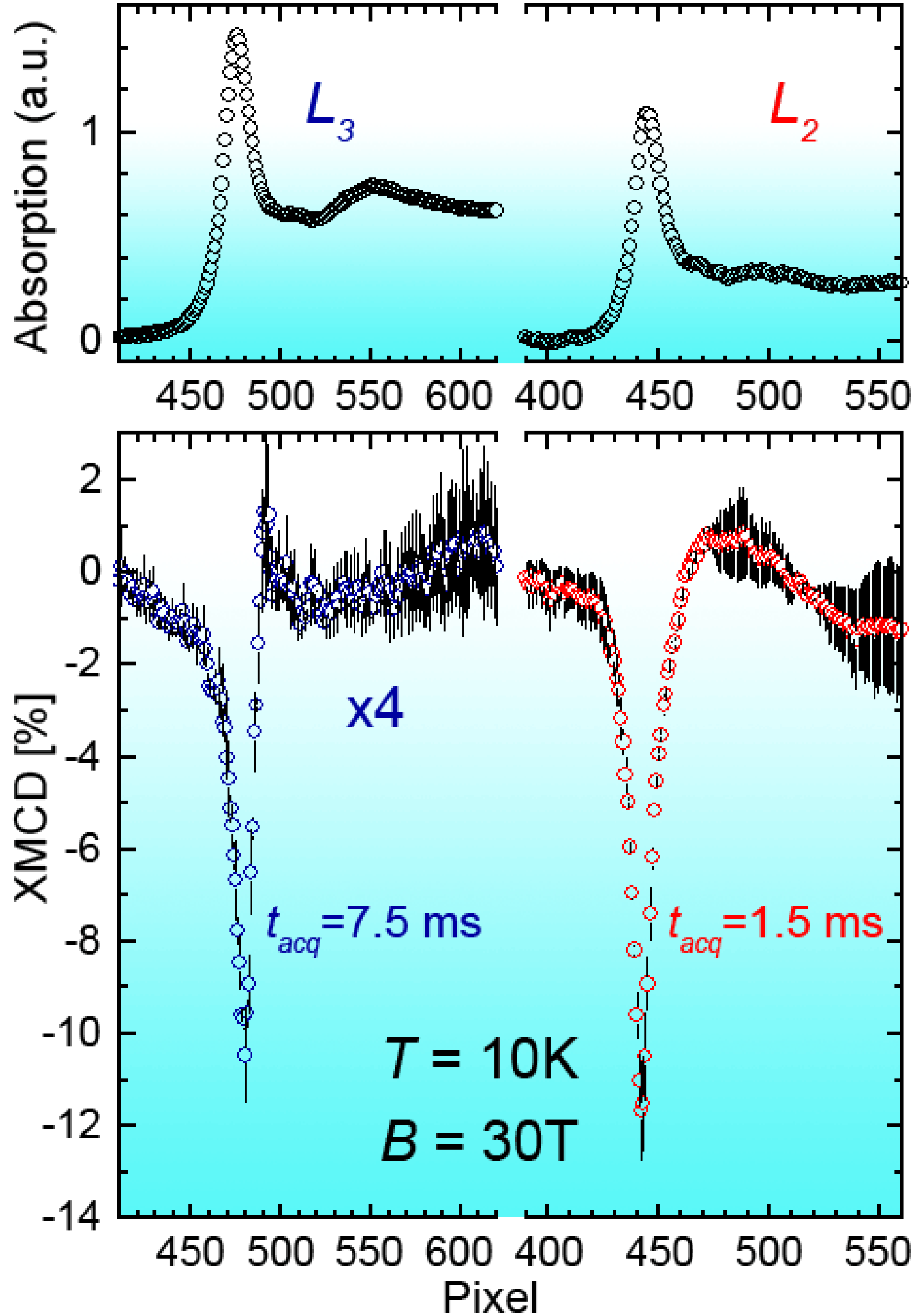
*P. Frings, J. Vanacken, C. Detlefs, F. Duc, J.E. Lorenzo, M. Nardone, J. Billette, A. Zitouni, W. Bras,G.L.J.A. Rikken, Rev. Sci. Instrum. **77**, 063903 (2006).*

XH fast, linear detector, developed at the STFC Daresbury and Rutherford Laboratories
germanium based microstrip detector head
built at the Lawrence Berkeley National Laboratory
Dr Paul Luke (J. Headspith, J. Groves, P.N. Luke, M. Kogimtzis, G. Salvini, S.L. Thomas, R.C. Farrow, J. Evans, T. Rayment, J.S. Lee, W.D. Goward, M. Amman, O. Mathon, S. Diaz-Moreno, *proceedings of NSS-MIC2007*).

M. Sikora
University of Science and Technology Krakow, Poland
Feb 3, 12H00

The perovskite Ca_2FeReO_6.





XAS and XMCD Re L_2 and L_3 edges at 30 T and 10 K on Ca_2FeReO_6.

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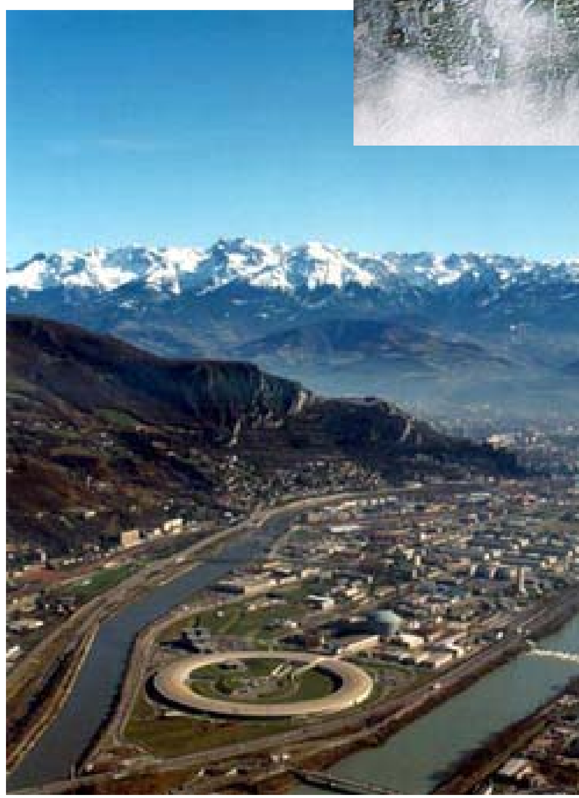

Thank you
for your attention