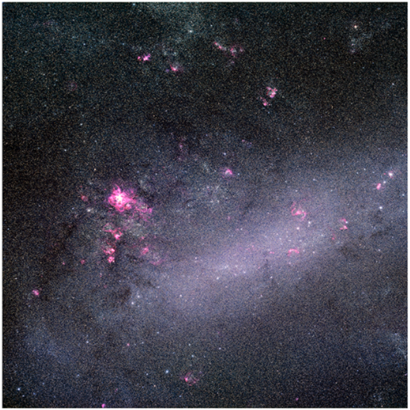
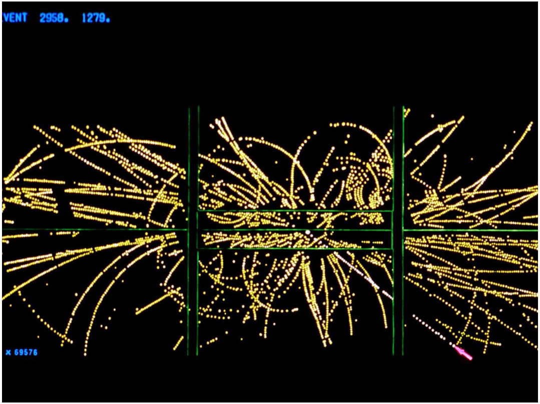
De Genève au Nuage de Magellan avec Michel S.

raconté par J. Rich, IRFU



UA1: $p\bar{p} \to W^{\pm} \to e^{\pm}\nu$



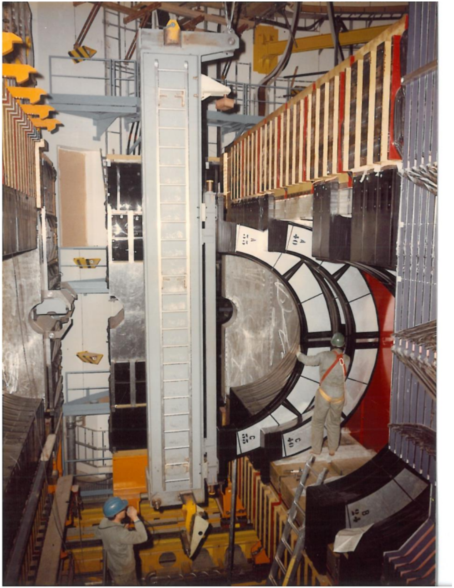
L'énergie des $e^{\pm}$ determinée par les "gondoles" (calorimetre electromagnetique construit à Saclay)

Groupe UA1 et Labo W/Z SACLAY en 1983

- C. Cochet, M. De Beer, D. Denegri, A. Givernaud, J. P. Laugier, E. Locci, M. Loret, J.J. Malosse, J. Rich, J. Sass, J. Saudraix, A. Savoy-Navarro, M. Spiro
- J. Calvet, J. Heitzman, P. Micolon, S.Palanque, J. C. Thévenin

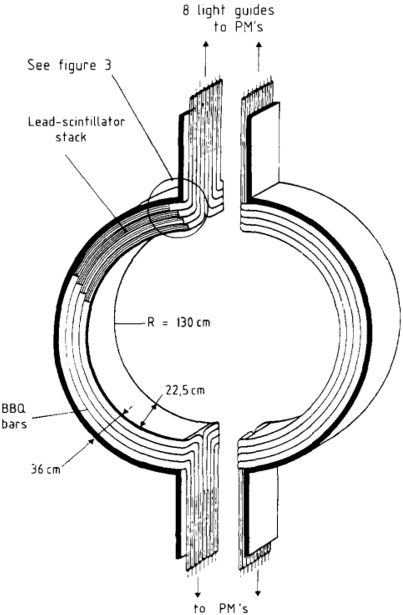



Les gondoles: sandwichs plomb-scintillateur



lumière de scintillation
→ BBQ wavelength shifters
→ lightguides
→ photo-multiplicateur

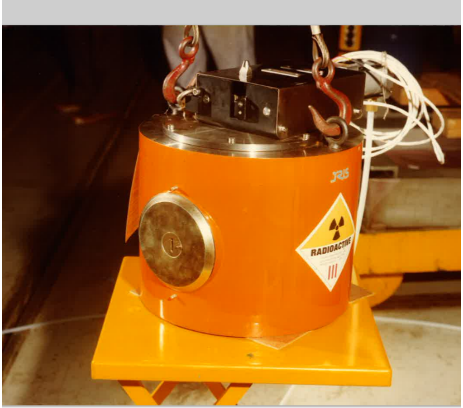
Le problème



Calibration?!

- Lumière au PM une fonction du point d'impact de $e^{\pm}$
- Pas de $e^{\pm}$ d'énergie connue dans les événements $p\bar{p}$!
- impossible de passer toutes les gondoles dans un faisceau de test!

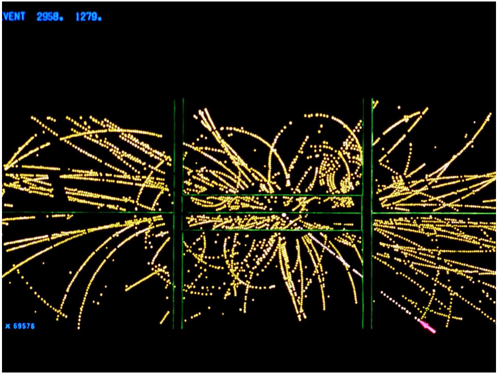
La solution de Spiro

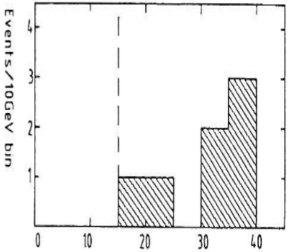


Source de 7Ci de Cobalt

- Cartographie des gondoles in-situ avec source
- Mesure courant induit sur le PM
- Passer qq's gondoles dans un faisceau test pour déterminer lumière($e^{\pm}$)/lumière(Co)

Les premiers $e^{\pm}$ vus par UA1





$E_{max} = M_W/2!$

Contributions de Michel à UA1

- Imagination (source Cobalt)
- Esprit Critique

L'esprit critique, Leçon 1

EXPERIMENTAL OBSERVATION OF ISOLATED LARGE TRANSVERSE ENERGY ELECTRONS WITH ASSOCIATED MISSING ENERGY AT $\sqrt{s}$ = 540 GeV

UA1 Collaboration, CERN, Geneva, Switzerland

G. ARNISON[j], A. ASTBURY[j], B. AUBERT[b], C. BACCI[i], G. BAUER[l], A. BÉZAGUET[d], R. BÖCK[d], T.J.V. BOWCOCK[f], M. CALVETTI[d], T. CARROLL[d], P. CATZ[b], P. CENNINI[d], S. CENTRO[d], F. CERADINI[d], S. CITTOLIN[d], D. CLINE[l], C. COCHET[k], J. COLAS[b], M. CORDEN[c], D. DALLMAN[d], M. DeBEER[k], M. DELLA NEGRA[b], M. DEMOULIN[d], D. DENEGRI[k], A. Di CIACCIO[i], D. DiBITONTO[d], L. DOBRZYNSKI[g], J.D. DOWELL[c], M. EDWARDS[c], K. EGGERT[a], E. EISENHANDLER[f], N. ELLIS[d], P. ERHARD[a], H. FAISSNER[a], G. FONTAINE[g], R. FREY[h], R. FRÜHWIRTH[l], J. GARVEY[c], S. GEER[g], C. GHESQUIÈRE[g], P. GHEZ[b], K.L. GIBONI[a], W.R. GIBSON[f], Y. GIRAUD-HÉRAUD[g], A. GIVERNAUD[k], A. GONIDEC[b], G. GRAYER[j], P. GUTIERREZ[h], T. HANSL-KOZANECKA[a], W.J. HAYNES[j], L.O. HERTZBERGER[2], C. HODGES[h], D. HOFFMANN[a], H. HOFFMANN[d], D.J. HOLTHUIZEN[2], R.J. HOMER[c], A. HONMA[f], W. JANK[d], G. JORAT[d], P.I.P. KALMUS[f], V. KARIMÄKI[e], R. KEELER[f], I. KENYON[c], A. KERNAN[h], R. KINNUNEN[e], H. KOWALSKI[d], W. KOZANECKI[h], D. KRYN[d], F. LACAVA[d], J.-P. LAUGIER[k], J.-P. LEES[b], H. LEHMANN[a], K. LEUCHS[a], A. LÉVÊQUE[k], D. LINGLIN[b], E. LOCCI[k], M. LORET[k], J.-J. MALOSSE[k], T. MARKIEWICZ[d], G. MAURIN[d], T. McMAHON[c], J.-P. MENDIBURU[g], M.-N. MINARD[b], M. MORICCA[i], H. MUIRHEAD[d], F. MULLER[d], A.K. NANDI[j], L. NAUMANN[d], A. NORTON[d], A. ORKIN-LECOURTOIS[g], L. PAOLUZI[i], G. PETRUCCI[d], G. PIANO MORTARI[i], M. PIMIÄ[e], A. PLACCI[d], E. RADERMACHER[a], J. RANSDELL[h], H. REITHLER[a], J.-P. REVOL[d], J. RICH[k], M. RIJSSENBEEK[d], C. ROBERTS[j], J. ROHLF[d], P. ROSSI[d], C. RUBBIA[d], B. SADOULET[d], G. SAJOT[g], G. SALVI[f], G. SALVINI[i], J. SASS[k], J. SAUDRAIX[k], A. SAVOY-NAVARRO[k], D. SCHINZEL[f], W. SCOTT[j], T.P. SHAH[j], M. SPIRO[k], J. STRAUSS[l], K. SUMOROK[c], F. SZONCSO[l], D. SMITH[h], C. TAO[d], G. THOMPSON[f], J. TIMMER[d], E. TSCHESLOG[a], J. TUOMINIEMI[e], S. Van der MEER[d], J.-P. VIALLE[d], J. VRANA[g], V. VUILLEMIN[d], H.D. WAHL[l], P. WATKINS[c], J. WILSON[c], Y.G. XIE[d], M. YVERT[b] and E. ZURFLUH[d]

Aachen[a]–Annecy (LAPP)[b]–Birmingham[c]–CERN[d]–Helsinki[e]–Queen Mary College, London[f]–Paris (Coll. de France)[g]–Riverside[h]–Rome[i]–Rutherford Appleton Lab.[j]–Saclay (CEN)[k]–Vienna[l] Collaboration

Spiro

L'esprit critique, Leçon 2

EXPERIMENTAL OBSERVATION OF EVENTS WITH LARGE MISSING TRANSVERSE ENERGY ACCOMPANIED BY A JET OR A PHOTON (S) IN $p\bar{p}$ COLLISIONS AT $\sqrt{s}$ = 540 GeV

UA1 Collaboration, CERN, Geneva, Switzerland

G. ARNISON [m], O.C. ALLKOFER [g], A. ASTBURY [m,1], B. AUBERT [b], C. BACCI [ℓ], G. BAUER [p], A. BÉZAGUET [d], R.K. BOCK [d], T.J.V. BOWCOCK [h], M. CALVETTI [d], P. CATZ [b], P. CENNINI [d], S. CENTRO [2], F. CERADINI [ℓ], S. CITTOLIN [d], D. CLINE [p], C. COCHET [n], J. COLAS [b], M. CORDEN [c], D. DALLMAN [d,o], D. DAU [d,g], M. DeBEER [n], M. DELLA NEGRA [b,d], M. DEMOULIN [d], D. DENEGRI [n], D. DiBITONTO [d], A. DiCIACCIO [ℓ], L. DOBRZYNSKI [j], J. DOWELL [c], K. EGGERT [a], E. EISENHANDLER [h], N. ELLIS [d], P. ERHARD [a], H. FAISSNER [a], M. FINCKE [g,1], P. FLYNN [m], G. FONTAINE [j], R. FREY [k], R. FRÜHWIRTH [o], J. GARVEY [c], S. GEER [e], C. GHESQUIÈRE [j], P. GHEZ [b], W.R. GIBSON [h], Y. GIRAUD-HÉRAUD [j], A. GIVERNAUD [n], A. GONIDEC [b], G. GRAYER [m], T. HANSL-KOZANECKA [a], W.J. HAYNES [m], L.O. HERTZBERGER [i], D. HOFFMANN [a], H. HOFFMANN [d], D.J. HOLTHUIZEN [i], R.J. HOMER [c], A. HONMA [h], W. JANK [d], G. JORAT [d], P.I.P. KALMUS [h], V. KARIMÄKI [f], R. KEELER [h,1], I. KENYON [c], A. KERNAN [k], R. KINNUNEN [f], W. KOZANECKI [k], D. KRYN [d,j], P. KYBERD [h], F. LACAVA [ℓ], J.-P. LAUGIER [n], J.-P. LEES [b], H. LEHMANN [a], R. LEUCHS [g], A. LÉVÊQUE [d], D. LINGLIN [b], E. LOCCI [n], M. LORET [n], T. MARKIEWICZ [p], G. MAURIN [d], T. McMAHON [c], J.-P. MENDIBURU [j], M.-N. MINARD [b], M. MOHAMMADI [p], M. MORICCA [ℓ], K. MORGAN [k], F. MULLER [d], A.K. NANDI [m], L. NAUMANN [d], A. NORTON [d], A. ORKIN-LECOURTOIS [j], L. PAOLUZI [ℓ], F. PAUSS [d], G. PIANO MORTARI [ℓ], E. PIETARINEN [f], M. PIMIÄ [f], D. PITMAN [k], A. PLACCI [d], J.-P. PORTE [d], E. RADERMACHER [a], J. RANSDELL [k], H. REITHLER [a], J.-P. REVOL [d], J. RICH [n], M. RIJSSENBEEK [d], C. ROBERTS [m], J. ROHLF [e], P. ROSSI [d], C. RUBBIA [d], B. SADOULET [d], G. SAJOT [j], G. SALVINI [ℓ], J. SASS [n], A. SAVOY-NAVARRO [n], D. SCHINZEL [d], W. SCOTT [m], T.P. SHAH [m], I. SHEER [k], D. SMITH [k], J. STRAUSS [o], J. STREETS [c], K. SUMOROK [d], F. SZONCSO [o], C. TAO [j], G. THOMPSON [h], J. TIMMER [d], E. TSCHESLOG [a], J. TUOMINIEMI [f], B. Van EIJK [i], J.-P. VIALLE [b], J. VRANA [j], V. VUILLEMIN [d], H.D. WAHL [o], P. WATKINS [c], J. WILSON [c], C.-E. WULZ [o] and M. YVERT [b]

Aachen [a]–Annecy (LAPP) [b]–Birmingham [c]–CERN [d]–Harvard [e]–Helsinki [f]–Kiel [g]–Queen Mary College, London [h]–NIKHEF, Amsterdam [i]–Paris (Coll. de France) [j]–Riverside [k]–Roma [ℓ]–Rutherford Appleton Lab. [m]–Saclay (CEN) [n] Vienna [o]–Wisconsin [p] Collaboration

No Spiro

Spiro Visionaire: 35 ans plus tard: toujours pas de supersymmetry!

Physique des particules hors accélérateurs

EXPERIMENTAL PARTICLE PHYSICS WITHOUT ACCELERATORS

J. RICH, D. LLOYD OWEN* and M. SPIRO

DPhPE, CEN Saclay, F-91191 Gif-sur-Yvette, France

Received February 1987

Contents:

Michel: “il faut s’instuire”

Physics Reports: Tout sauf les ondes gravitationelles!

Physique hors accélérateurs à Saclay en 1986-89

- Durée de vie du proton (Frejus)
- Neutrinos Solaire (Gallex)
- Matière Noire (?)
  Wimps standard: Ge crystals, B. Sadoulet à Berkeley
  Non-standard: (Spiro et al)

Strongly interacting dark matter?

A SEARCH FOR STRONGLY INTERACTING DARK MATTER

J. RICH [a], R. ROCCHIA [b] and M. SPIRO [a]

[a] *DPhPE, CEN Saclay, F-91191 Gif-sur-Yvette, France*

[b] *DPhG, CEN Saclay, F-91191 Gif-sur-Yvette, France*

Received 13 April 1987

A silicon semiconductor detector near the top of the atmosphere is used to search for strongly interactin
halo. The data exclude, as the dominant component of the halo, such particles with masses between ~ 2
Comparisons are made with a previously reported subterranean search for weakly interacting halo partic

Détecteur silicium embarqué en satellite

Charged Dark Matter?

IS THERE ROOM FOR CHARGED DARK MATTER?

J.L. BASDEVANT [a], R. MOCHKOVITCH [b], J. RICH [c,d], M. SPIRO [c] and A. VIDAL-MADJAR [b]

[a] *Institut de Physique Nucléaire, B.P. 1, F-91406 Orsay Cedex, France*
[b] *Institut d'Astrophysique de Paris, 98 bis boulevard Arago, F-75014 Paris, France*
[c] *DPhPE, CEN Saclay, F-91191 Gif-sur-Yvette Cedex, France*
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Received 2 November 1989

It has recently been suggested that galactic dark matter halos could be made of very heavy charged particles (20–1000 TeV). We show that present observations and experimental limits are hardly compatible with such a scenario. The best chance, if any, would be in the upper mass range near or above 1000 TeV which can be unambiguously explored by specific experiments that we discuss.

Dans la mer?

LUME 68, NUMBER 8 PHYSICAL REVIEW LETTERS 24 FEBRUARY 1992

Search for Superheavy Hydrogen in Sea Water

P. Verkerk,[1] G. Grynberg,[1] B. Pichard,[2],[a] M. Spiro,[2] S. Zylberajch,[2] M. E. Goldberg,[3] and P. Fayet[4]

[1]*Laboratoire de Spectroscopie Hertzienne de l'Ecole Normale Supérieure, Université P. et M. Curie, BP 74, 75252 Paris CEDEX 05, France*

[2]*Département d'Astrophysique de la Physique des Particules de la Physique Nucléaire et de l'Instrumentation Associée, Centre d'Etudes Saclay, 91191 Gif-sur-Yvette CEDEX, France*

[3]*Institut Pasteur, 28 rue du Docteur Roux, 75015 Paris, France*

[4]*Laboratoire de Physique Théorique de l'Ecole Normale Supérieure, 24 rue Lhomond, 75231 Paris CEDEX 05, France*

(Received 29 July 1991)

We report the results of an experiment designed to search for superheavy isotopes of hydrogen. Based on the centrifugation of sea water, followed by atomic spectroscopy, it is sensitive to large masses from 10^4 up to 10^8 GeV/c^2. The relative abundance of such hypothetical atoms, compared to ordinary hydrogen, is found to be less than about 6×10^{-15}. This may be used to exclude charged dark matter particles between 10^4 and 10^7 GeV/c^2.

Aussi la solution du probleme des ν solaires?

, NUMBER 11 PHYSICAL REVIEW LETTERS 10 SEPTEMB

Searching for the Cosmion by Scattering in Si Detectors

D. O. Caldwell, B. Magnusson, and M. S. Witherell
Physics Department, University of California, Santa Barbara, California 93106

A. Da Silva and B. Sadoulet
Physics Department, University of California, Berkeley, California 94720

C. Cork, F. S. Goulding, D. A. Landis, N. W. Madden, R. H. Pehl, and A. R. Smith
Lawrence Berkeley Laboratory, Berkeley, California 94720

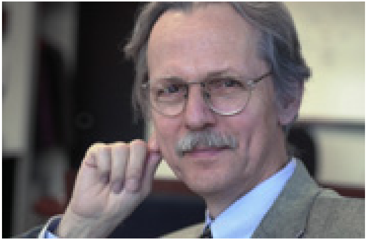
G. Gerbier, E. Lesquoy, J. Rich, M. Spiro, C. Tao, D. Yvon, and S. Zylberajch
Département de Physique des Particules Elémentaires, Centre d'Etudes Nucléaires de Saclay, F-91191 Gif-sur-Yvette CEDEX, France

(Received 5 June 1990)

A new particle, the cosmion, has been proposed to be the dark matter of the Universe and to explain the solar ν deficit by cooling the solar core to reduce ^{8}B ν production. Such cosmions in the galactic halo would scatter from nuclei in terrestrial detectors. Measurements were made in Si ionization detectors in a very-low-background environment down to energies of 1.1 keV. These results exclude nearly all of the mass range possible for cosmions with coherent nuclear interactions.

PACS numbers: 95.30.Cq, 14.60.Gh, 14.80.Pb, 96.60.Kx

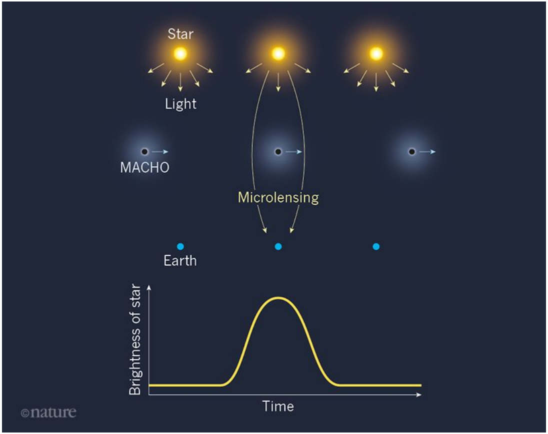
Halloween, 1989: Charles Alcock à Berkeley



Matière noire en forme d'étoiles sombres peut être détectée par gravitational (micro)-lensing.

(Idée de Paczynski, 1986)

Microlensing



Probabilité
$\approx (v/c)^2 \approx 10^{-6}$

(Plus simple que pour les WIMPS!)

Il faut monitorer $\approx 10^6$ étoiles
$\Rightarrow$ Les nuages de Magellan.

1990: Naissance d'EROS: Spiro at work!

Il fallait:

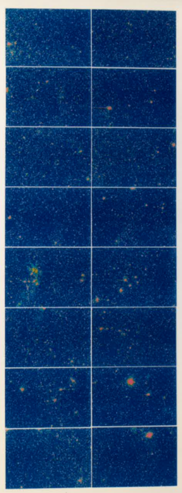
- Recruter des physiciens: Saclay, LAL, INSU
- Apprendre l'astronomie
- Politiquer à Saclay et à l'ESO
- Trouver un téléscope: ESO Schmidt et GPO
- Construire Camera CCD (Pierre Bareyre)
- Traiter 10^6 étoiles $\Rightarrow$ informatique

  Eric Aubourg

  Eric Lesquoy

  Luciano Moscoso

The T40 et camera Eros-1

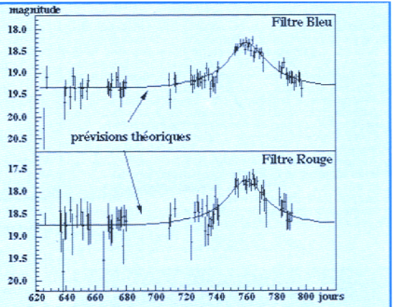


Un événement: 1993

LETTERS TO NATURE

Evidence for gravitational microlensing by dark objects in the Galactic halo

E. Aubourg*, P. Bareyre*, S. Bréhin*, M. Gros*, M. Lachièze-Rey*, B. Laurent*, E. Lesquoy*, C. Magneville*, A. Milsztajn*, L. Moscoso*, F. Queinnec*, J. Rich*, M. Spiro*, L. Vigroux*, S. Zylberajch*, R. Ansari†, F. Cavalier†, M. Moniez†, J.-P. Beaulieu‡, R. Ferlet‡, Ph. Grison‡, A. Vidal-Madjar‡, J. Guibert§, O. Moreau§, F. Tajahmady§, E. Maurice∥, L. Prévôt∥ & C. Gry¶



Courbe de lumière de l'évenement n° 1
L'accroissement de magnitude observé correspond à un facteur d'amplification de 2,5

Le Monde et International Herald Tribune

The Dim Stars We Can't See May Be a Heart of Darkness

NEW YORK (NYT) — Two scientific teams reported they had independently observed what could be evidence that some of the invisible, or dark, matter making up much of the mass of the universe exists in the form of stillborn or extremely dim stars at the edges of galaxies.

Such objects, known as Massive Compact Halo Objects, or MACHOs, have been hypothesized for years as likely candidates for dark matter. The acronym was chosen to contrast with theories invoking exotic subatomic particles as yet undiscovered bearing the name WIMPs, for Weakly Interacting Massive Particles.

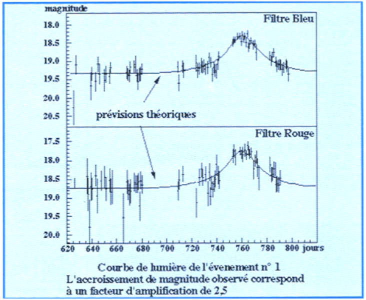
If the new findings of MACHOs on the fringes of the Milky Way galaxy are confirmed by further sightings, astrophysicists said, this would be the first observational breakthrough in astronomy's concerted search for the mysterious dark matter.

It would be the first identification of the unseen matter that causes galaxies to weigh 10 times as much as they appear to in visible light or other detectable radiations. The existence of these greater masses has been inferred by their gravitational effects on the shape and motion of the galaxies, but its form has eluded detection.

The discoveries were announced in cautiously worded statements at two scientific conferences in Italy. American and Australian scientists said they hurried to report their results when they learned that a French team planned to make public the results of their own similar but independent observations.

The American-Australian team, led by Dr. Charles Alcock of Lawrence Livermore Laboratory in California, reported that in monitoring 3.3 million stars for a year, they had detected one remarkable event that could reveal the existence of dark matter in the form of MACHOs.

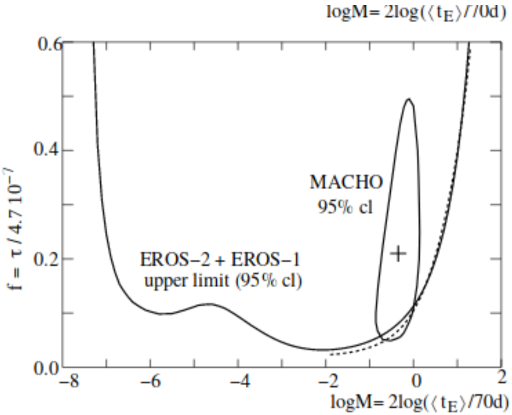
L'esprit critique, Leçon 3



Mais c'est une étoile B-e!
$\Rightarrow$ suspension temporaire de l'E.C

"To every thing there is a season..." (Ecclesiastes 3:1)

L'esprit critique, Leçon 4



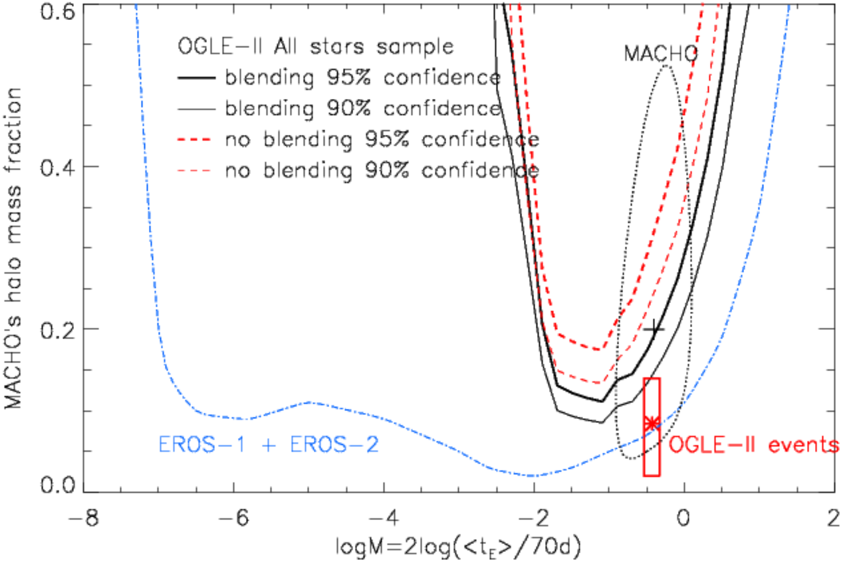
Tisserand et al. (2007):

"Limits on the Macho content of the Galactic Halo from the EROS-2 Survey of the Magellanic Clouds"

473 citations

Macho DM exclue pour $10^{-7} M_{\odot} < M_{macho} < 10 M_{\odot}$

OGLE confirms



Microlensing des Supernovae

Zumalacarregui & Seljak (2018): exclu $M \approx 30 M_{\odot}$ (Ligo BHs)

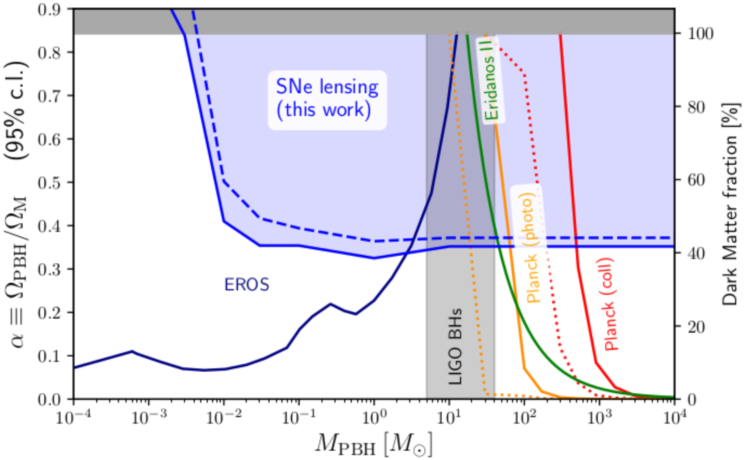
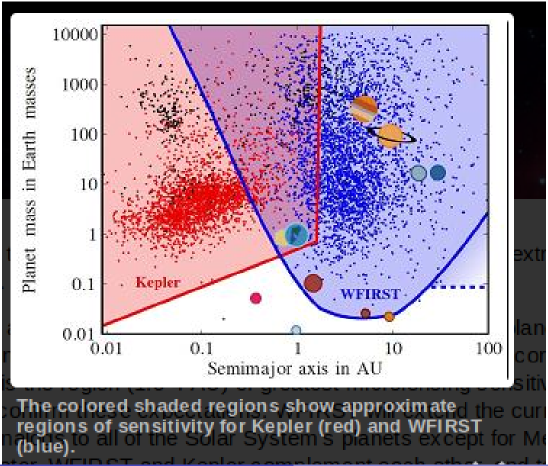


FIG. 3. Bounds on the abundance of PBHs as a function of the mass (95 % confidence level). The analysis of SNe lensing

Legacy of EROS

- Microlensing: pas de matière noire mais des planetes
  Jean-Philippe Beaulieu (IAP)

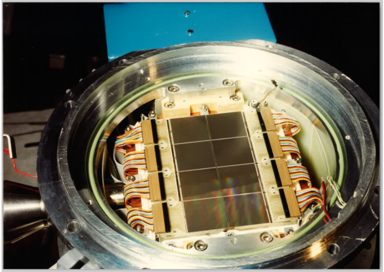


Legacy of EROS

- Microlensing: pas de matière noire mais des planetes
- Cameras CCD au CEA: 3 caméras les plus grandes du monde

EROS-1 $\rightarrow$ EROS-2 $\rightarrow$ Megacam

Caméra Eros-2



Legacy of EROS

- Microlensing: pas de matière noire mais des planetes
- Camera CCD au CEA: 3 caméras les plus grandes du monde
- Astonomie amateur @ CEA:
  EROS-1 $\rightarrow$ EROS-2 $\rightarrow$ Archeops$\rightarrow$SNLS$\rightarrow$BOSS$\rightarrow$DESI
  Eric^2, Pierre, Christophe, Alain, Luciano, Jim, Michel^2, Sylvain
  $+ \approx 25$ thésards
  $\rightarrow$ Eric, Etienne, Jean-Marc, Christophe^2, Jean-Baptiste, Nathalie, Vanina, Jim
  $+$ thésards et postdocs (le plus grand groupe du DPhP!)

Legacy of EROS

- Microlensing: pas de matière noire mais des planetes
- Camera CCD au CEA: 3 caméras les plus grandes du monde
- Astonomie amateur @ CEA:
  EROS-1 $\rightarrow$ EROS-2 $\rightarrow$ Archeops$\rightarrow$SNLS$\rightarrow$BOSS$\rightarrow$DESI
  Eric^2, Pierre, Christophe, Alain, Luciano, Jim, Michel^2, Sylvain
  $+ \approx 25$ thésards
  $\rightarrow$ Eric, Etienne, Jean-Marc, Christophe^2, Jean-Baptiste, Nathalie, Vanina, Jim
  $+$ thésards et postdocs (le plus grand groupe du DPhP!)
- $+$ LAL, LPNHE, APC, CPPM........

Spiro: executive summary

- bon gout scientifique
- curiosité
- imagination
- esprit critique
- sens de l'humeur

et

- se focaliser sur l'essentiel
- se focaliser sur le possible

Mais surtout: Organiser et motiver une équipe