

VIIth Topical Workshop on Modern Aspects in Nuclear Structure

The Many Facets of Nuclear Structure

BORMIO 3-8 February 2025

SYMPOSIUM on Resonances and related topics

for Angela Bracco University retirement

Edoardo G. Lanza INFN - Sezione di Catania



fessor at the University of Milano and she is associated to INFN. Her research experience is in nuclear structure and she obtained relevant results on the giant dipole resonance at zero and finite temperature. She was involved in the realization of complex detection system for gammaray built in European collaboration (EUROBALL, RIS-ING and AGATA). In 2005-2011 she chaired the Nuclear Physics board of INFN and presently she is the chair of NuPECC (the European expert committee for Nuclear science).

Angela Bracco is a full Pro-

Angela CV (probably not the last one)

(Meuropass	Curriculum Vitae	Angela Bracco	(Meuropass	Curriculum Vitae	Angela Bracco	(Meuropass	Curriculum Vitae	Angela Bracco
			Organisational / managerial skills	My research is in the field of experimental Nuclear Physics nuclear structure). In connection with my experience in m	with focus on gamma spectroscopy for maging meanch funding and personnel	Jab-related skills	Wy activity in Scientific committees of Laboratories an	Institutes is listed below
PERSONAL INFORMATION	Angela Bracco			I had the charce to be in "hary committee and parets of autophysics, autoparticle, particle, nuclear and accelerati and applications. In addition I did evaluation work (the ti of APVUR (Gruppe expert) Valuators). DC paret member	aung with several dimension activities: ir physics, new technical developments mex, in 2011 e in 2015 member of GEV for four times, up to 2020)		Chair of the International Program.Molvary Committee Chair of the Inter, Scientific Committee of the project Chair of the International Scientific Council of the Inter-	of Nubina Center RKDN (2017-2018) HE-ISOLDE at CERN (2011-2017) Intel IREU/CEA (Engrava) (2012-2018) The
	Present work address: Dipartimento di Fisica, Università di Mil Celoria, 16, 20133 Milano, e-mail: Angela.Bracco@mil.infn.i	lano, via It		President of the Italian Physical Society (since Jan	ary 2020)		council deals with all activities of the institute: astroph accelerator physics, new technical developments and Member of the Scientific Council of the ELI Facility (the	etics, astroparticle, particle, nuclear and applications. • pillar in Bucarest from 2015 to present).
WORK DIPERIDICE				 MUR (Ministry of Research and University) represe directors of INFN (from August 2011 to August 201 Only of the Nursear Desire Board of INFN (CSU). 	stative member in the Board of 5) mm Annii 2005 to Gostember 2011.		 Member of the Scientific Committee of Nebina Cente Japan) (from 2008-2012), Nember of the Program Advisor (2015-2016), Member of the RIKEN Advisory Committee 	r at the research institute RMIN (Tokyo, committee of the RMIN Nishina Center 2019)
	Full professor of Physics (Experimental Physics) at the Univer 2002 to present).	sity of Milano (from		This responsibility position implied extensive work different projects in Nuclear Physics in the Italian LNGS and LNP), at CDN, and at several foreigner	to organize the funding of many aboratories LNL, LNS (and partly in laboratories such as GS, GANL,		Member of the scientific committee of the cyclation is present) Member of the Scientific committee of the institute of Member of the Scientific Committee of Deach Institute	Romony at 9 J in Cracow(Hom 2014 to Rysics in Heldinki (Finland) (2018 In 2019/CMPS, Institute for Nacione
	Associate professor of Physics (Experimental Physics) at the L (from 1998 to 2002)	Jniversity of Milano		scale, and two others. The activity included also t triennial plans, annual reports of the results and the international evaluation committee of INFN.	se preparation of road map and luture planning to be presented to		Particle and astroparticle Physics)(2011-2014) and memb Physics Institute at Orcay (IPNO) (2012-2016). Number of the Scientific Committee of the germ	or of the Scientific Committee of Nuclear an Laboratory GS (Darmstadt, Germany)
	Researcher (Experimental Physics) at the University of Milano (from 1983 to 2002)			 Member of several selection committees for INFN and chair of an INFN Committee for selection at national is 200 participants) and chair of a committee for select 	University personnel. In particular, I was wel for Advanced researchers (more than on at national level of first level.		(2009-2015) and of the Scientific Committee of the cent (Germany) for Nuclear Physics (2009-2015). Nember of the Scientific Council of the BJI Facil	er of the Helmholtz lutititute at Nainz by (the pillar in Bucarett from 2015 to
ENCATON AND TRAINING				researchers of INFN. Nember of several university co different levels at several Universities in Italy and in I	smittees for selection for positions of larope (Leuvain and Darmstadt).		present). Member of the Scientific Committee of Nahim (Takyo, Japan) (from 2008-2012). Member of the Program Control (2014) 2014: Similar Device Device Form	Center at the research institute RMDN Advices Committee of the RMDN Nithina
	Vancouver and University of Manitoba which gave the Ph.D).			 Member of the governing board of the EU project t in FP7) and responsible of one working package(20 the preparation of project calls to be funded by so 	lapliet (BAMET for Huclear Physics 08-2011). I particular I worked in weral European funding agencies.		Nember of the Scientific committee of the cycle Nember of the Scientific committee of the cycle Nember of the Scientific committee of the instit	tron laboratory at FJ in Cracow(2014 - ute of Physics in Helonici (Finland) (2018- Dentine in Helonici (Finland)
PERSONAL SALLS	Laurea (Master) in Physics (1979), Università degli Studi di Mi	ino		 Responsible at National level of a PRIN MUR proje instrumentation for Radioactive beams (2013-2015) 	ct (competitive funding) on)		Char the scenetic contracted of the institute of International Parallel of Research Eurofice Associate	Phytics in metanic (Financi) (2221-
Mather tongue(c)	Italian			 Chair of NuPECC - the nuclear Physics expert com Foundation, from January 2012- December 2017. I NuPECC is the volume " Nuclear Physics for Medic Management (Section 2017). 	sittee of the European Science knong the activities made for se": "The long Range Plan in the long Range Plan in		 Nember of the expert panel for Nuclear and Part Agency FWO (from 2010-2018) 	cle physics of the Belgian Funding
Other language(s)	DESILINGING PERIOD	NUTRG		for the European Landscape for Physics. • Chair of the WGP (nuclear physics) panel of IUPAP 2012).	jelected in 2019, and member since		 Nember of the expert panel of Academy of Finla Nuclear and Accelerator Based Physics (October Nember of the committee for NICENN (Spanish m) 	nd Centre of Excellence Programme - 1010- September 2012, August 2018) nistry of Science and
English	Eigen Proficient User C1 Proficient User C1 Proficient User	C1 Proficient User C1		 Member of the Executive Board of the European Pt Member of the CISA (Committee for international Sc Physical Society). 	ytical Society (from 2014-2018). entific Affairs) of the APS (American		Nadrid, Hay 2011 and October 2017). Member of the Nuclear Physics Grants Panel of th Council in the UK (October 2010-June 2011, 2013-20	e Science and Technology Facilities
French	Fresh Independent user Independent user Independent user	uter independent uter		My activity in evaluation panels for EU commission, instite Nember of several panels for the EU commission in di	utions and Agencies is listed below: levent calls and framework programs.		Nember of a review panel for the USA Departme 2018) Member of a grant selection panel for NSERC (Ott	nt of Energy DOE (Washington, Uka, Iwa, Canada, 2018)
				Member of the List, panel for involution and interconnet HORIZEN2020) for the Starting grants (in: 2014-2016-201 Panel member (evaluation and election) for calls with "Interpreted & tricking" and "Basian Studies" (2002-2003 a	physics projects (section vie in 8-2020), thin the FP6 and FP7 programs, of 2016b and in 2005 for "Benearth and		Member of a Polish grant selection panel (from 202 Other Past responsabilities and participation in Scientifi media associate	1) c committees of Laboratories, institutes
Teaching and communication	General Physics - Electromagnetism and optics for Physics students (from 1	(983-to 1998)		Training Networks, Marie Curie Selows". Member of the Physics Expert Panel (called GEV) of JP Research from 2011 up to May 2013. I was the coordinator of	VUR for the evaluation of the Italian If the sub-ganel for nuclear, particle and		Nember of the Working Group of OEED (Global S Economic Cooperation and development) on N Nember of the Scientific Committee of the labor	cience Forum Organization for scienz Physics (2006-2007) tory GANIL (France (2007-2010)
0.00	General Physics - Electromagnetism and optics for Chemistry students (200 Laboratory of gamma spectroscopy for Physics students (1994-present) Introductory Nuclear and Particle physics (2004-present)		antroparticle physics. WVIR CCV remotes also for the second evaluation in 2015-2016. Responsible for the Nations and particle physics evaluation of several Greek Institutes (February 2014), nominated by the Greek Ministry of Research.			Rember of the Scientific Review International Committee of the INFN LHL and LHS liaboratories (2004 March 2008) Rember of the scientific Advisory Committee (SAC) of the Facility SPRAL2 (in the ESFRI las) from 2001 to 2004		
	Number of the board of Graduate School in Mysec (2003) - Supervisor for undergraduate theses for the first level (21 theses) and Nate Supervisor or co-supervisor for graduate theses (PLD): 14 theses Number and chair of parameter committees for PL predication in Milano. Indu	r 34 theses		 Mamber of the saview panel of the mambers intogram (GS), February 2009), Nember of the Review Panel of the 1 Symmetry and Stability of Matter and Antimatter" (Main summer of an analysis in seel for the Deech writigs. 	me "Hypecs of Hadrons and Nacah" leinhoiz institute Mainz"Structure, , April 2009) 21 (Dhairun der deux infiniti hald in		Nember of the Program Advisory Committee of the Labo Town * (from 2000 to 2002) and Member of the Program Laboratory (2015) Strasburg (from 1008 to 2002)	atory "National Accel Center of Cape Advisory Committee of the CNRS
	Annual and the transmission of Pit of galaxies in Patric, say			April 2010. Panel Hember of the AMR (Agency National Rea 	rche, France) from 2018. e for "Graduate Schools" for the ber of the Cluster of eccellence DFG		contrasty occurrence (non-room of source).	
				panel in 2017. Member of the Review Panel of the Helmho My activity as remote referee has been also very inters	tz institute in Julich (December 2017). a.			
	C European (John, 202) 2018 mangana, unliking mangan me	Page 17.9		Charapter Drive, 322 328 europea.ordelig.europa.eu	Page 279		C European Union, 2022 2018 numpers, celluling: numper-sec	Nege 179
Meuropass	Curriculum Vitae	Argela Bracco	(Meuropass	Curriculum Vitae	Angela Bracco	Reuropass	Curriculum Vitae	Angela Bracco
Digital skills	NEP-INSTANT			and of the feloweble, the publication of this curriculum is the web section "Amministractione transparente", "Consulent) e cullaborat	dar of Università degli Studi di Milano II the all'.	Research collaborations		
	communication communi	Hubben salving ser Independent user	Date	Signature		Hember of the Steering (from 2009) - Elect Hember of the Steering	Committee of the AGATA European collaboration for nu ed chair in 2020 for 2022-2023 Committee of the RSING collaboration at GSI	clear spectroscopy with gamma-rays
	Sevels Back von - Independent von - Proficient von Digital competences - Señ economie gital Backers with come of MT configure		(stepperaces		Non 2001 to 2003 general spectraccopy with adductive learns 4.00/i. Hender of the Service (2003) description of the Statistical Lipping and California for general spectraccopy (from 1994 to 1994). National responsible of URN Nuclear Physics requestives in susceed NECTOR, POINAR, PAREE from 1992-1994 dealing with the single of gener resonances and responsible for Alikou of the SN Are address and EXERCAL address and the SN Are address and t			
	Lacquire my competence during my research activity requiring use of comp	uter and programming.	Of December 2024					
Other skills	Teaching and outwarch activity					chairship of the scie Visitor Scientist at. TRUMF (198	ntific committee of Nuclear Physics of ININ (CSN3). (; at Oak Ridge National Laboratory (in 1985 and in 1986; a	the
ADDITIONAL INFORMATION Publications	Co-author of 350 research papers on scientific journals (includ	Ince 30 FRL+ 30 FLB, a	ANNEX : Short descr	ription of the scientific activity and se	ected publications.	Niels Bohr Institute (Copeeha	gen) for several periods of 2 to 3 months from 1987 to 200	£.
Presentations Conference seminars Outreach	Phys. Report and a Report in Progress Physics) plus approxima proceeding volumes (many in special volumes of journalis), (h The number of co-authors varies from 10 to around 50 which is typ	telly 180 papers on factor 49). Ical for the field in	Short description of the sc	ientific activity		I have organized 10 inter constrined meetings for	mational conferences, including one Enrico Fermi Scho the Eli-Ensuet NuRHET project and several other colleb	4 in 2010 (Varenna). I have also cratics meetings. Conscirution in
	 Presentation of 85 invited talks at international workshops an summary talks, and two keynote talk at 4 large conferences, 8 and IND215 and Zakopane2016 and one SIF relatione eccentale 	d conferences (2 DMS2012, ARIS2014 H plus 25 seminars	The research activity starting from dynamics. Before, and in particuli rembies with searching induced by	n 1985 is in experimental nuclear physics with focus in the fiel ar during the PH.D work, research was made to study the nucle is intermediate asserts rendrow jut the information T281BM. Van	d of Nuclear Structure and reaction on force and the nucleon few-body means Constants	Milano of the Simposiur I was member of the into	n Italy-RHZN in 2012 and of NuSTAR week in September emational Advisory. Committees of several (25) Internat	2018. Ional Conferences.
	given at Universities or Laboratories. Organization of 10 International Conferences. • Author (with two other colleaguest) of a book. "Can't Resources: Muchae throating at finite temperature" biologing to the series" <i>Collemptary Concepts</i>		Most of the experimental work of my research activity was made employing heavy ions reactions and gumma spectroscopy. In this connection the research was and is being carried out as a nember of several fungement calaborations accurding detectors must for gumma-ray spectroscopy. The nort reverse calaboration is <i>Addita</i> , as nowning for gumma-ray spectroscopy based on a nowni tracking			 Chair of the Program Committee of the international Nuclear Physics Conference IMPC013 (this is the largest conference in the field, covering all togics of modern Nuclear Physics, some at the boundary with particle and astroparticle physics and of LAPPC 2018 (dialogna) 		
	 In Project* Editor for 4 volumes of Conference Proceedings, one volume to Envico-Fermi School in Varenna of the Italian Physical Society Beforce of several research in Ultravet scientific in small 	being lectures of the	technique. The finit phase of the J G2 and GANE. I am presently inv in the past years I was member of #M_JNIN_Lemenr. Defends and	EATX array, called demonstrator, was constructed and plint ex olved in experiments for the study of Gast Resonances in RM the international collaboration HORBALL and HECTOR (Heles B of the mark Instead European collaboration (LIROBAL) insertion	periments were carried out is LNL-NPN, N and Osaka, Japan. ohr Institute, Copenhagen) and GASP endurine 1996-2007 ar 1 M JMDN and	 Responsible in 2014 of th Fisica). 	te section on " Nuclear and Particle Physics" for the an	ual meeting of SF (Società Italiana di
	 Outreach activity: Editor in chief of Nuclear Physics News; Cor journal Autometrie of INFN, Notiziario Università di Milano. Ne committee of Energe-Lab in Lombardia. 	stributor to the ember of scientific	Strathourg). After 2002, using a large fraction CLARA IN LINL. The RSING callal	of the EUROBALL equipment, two new experimental set ups w paration has conducted very new studies of unstable nuclei wit	we constructed, RGNG(GS) and PRSMa- radioactive beams at the laboratory GS	Relation with industry and	technology transfer	
Editor of Sci. Journals	 Co-editor of European Physics Letters (EPS journal) (2015-202) Editor of the international scientific journal. Nuclear Physics J 	0) and Supervisory 8 (Elsevier) (2018-)	(Darmstadt-Germany). Personal contributions of some re collective nuclear excitations at t	levance were given in the experimental data taking and they be extreme conditions of thermal excitation, angular moment	concern the study of the properties of umand koppin. Indeed a number of	During the time I was chair of the or indirectly with Industries an In addition with my group in M	 Nuclear Physics Board of INFN I had the chance to inte d companies involved in the construction of our detect lano we are developing detectors and related electronic orders and related to the second second	act directly on systems. It
	As president of SIF I am the Director of the journals "organi della Socie rivista del nuovo Cimento-joubblicata con Springer and Nature), il Nuov Quaderni di Fisica, il Nuovo Saggiatore.	tà Italiana di Fisica : La is Cimento, Il giornale e	experiment dedicated to the sta- interesting results on nuclear stru- detectors for high-energy gamma	by of the gamma decay of the gast dipole reconance, were per cture at finite temperature were obtained using the above lar -rays, developed and constructed with my group in Milano.	ormed under the Mano regorization, or arrays and including additional	context we have had for sever Recently, the company CAIN version of an electronics mod	I years contacts and collaborations with companies an showed much interest is developing together with our ule for scintiliators, whose main structure was decines	i industries. proup a commercial at the Milano ININ
Honours and awards	Member of Academia Europana -vice chair of the Physical Engineering Scient Member dell' Istituto Lombardo Accademia di Scienza e Lettere Consecondire Member of the Ecisoria Academix of Science	ce Panel	Presently within the AGATA inter- degrees of freedom identified wi frequency small amplitude vibrat	rational collaboration, I am committed in the realization of re th high-energy gamma-ray emission. These studies are relevant ions in the region around the nucleon binding energy. They are	wancillary detectors to study nuclear to understand the response for high also important for the description of the	section for our applications. T transfer agreement (with royalt	his resulted in the funding by CADN of a post-doctoral iss for ININ) for the electronics module.	ellowship and in a technology
		_	Additional experimental work, stil Additional experimental work, stil ANL(Chicago, USA) with the array With all these artistics the array	wing explosions of super-noise. It in the field of nuclear structure with gamma spectroscopy, w Gammasphere and GANE (Leen, France) with the array DDG and Allano, that I have been constitution for the last 25 users	s made during the years at M. Instrument a well ascretized expertise			
MADES	Short description of the scientific activity and selected publications.		In the field of nuclear structure a necessary to study continuum spe are in international collaboration	t finite temperature. The expertise is also in the development ctra emitted from nuclear rotations and vibrations. The exper s and concern the investigation of collective modes in nuclei f	of experimental and analytic techniques mental activities planned for the future ir from stability, which are mostly	Selected publications of A	ngela Bracco (out of >350 co-authored in re	fereed journals)
			created using radicactive beams The construction phases of the co	(hom SPES_INPN, CERN-EGUED and GANIL-SPIRAL2). mplex detector arrays, mentioned above, required relations as n mechanics, electronics and computers	d common developments with	1) Measurement of the Gamma-Ray Plasmas Dal Molin, A; Narcer, G;	to-Neutron Branching Ratio for the Deuterium-Tritium ()A Bracco; Tardocchi, M	Reaction in Magnetic Confinement Pution
Personal information I authorize the has Reautorizers BJ 679/2016 (Seneral Reau	nding of personal information in this curriculum, according to D.Lge n. THATE and Soliavin Instance concerning that Protection or GBDP and art. 7 of Entwenty-Regulations concerning	ng modifications and e protection of personal	In this research field she supervi	ued the activity of 10 post-doctoral fellows. One fellowship	vax obtained from funding from	 Juli JD 2004 WITSCAL REVIEW LE Search for the y decay of the nati Zhane. G Aug 2024 PHYSICS LETT 	11045 133 (5) 10w near-threshold proton resonance in 118 Bottoni, 5; 105 8055	Corbari, G; (); A. Bracco,
information.	Lasthorbe, according to Digs 14/33/2016. 33 cancerning transparency, in case of car	element of the position	Industry (from CAEN) Agood fraction of the master and the University of Nilano, at INFN	Ph.D supervised students, with research projects within the ab in foreigner research institutions, and as managers in compar-	we collaboration, have now positions at ies performing research.	1) High-spin states in 212Po above 1 LETTERS (2022)8834.	the o-decaying (18+) isomer Zago, L; Gottardo, A; ();	L Bracco, Wollensheim, PHYSICS
	(Automotivity WWW) and a state of			Characteristic WINNEL and a state and		4) Spectroscopic quadrupole mome PHYSICAL REVIEW C101	nts in 1248a, Clément, E; Lemasson, A; (); A. Bracco,	Dobin, JJV, Jan 30 2023
(Maropass	Curriculum Vitae	Argela Bracco	(Metropass	Curriculum Vitae	Angela Bracco	aropass	Curriculum Vitae	Angela Bracco
5) Gamma spectroscopy with AGAT. Duchline, G; (); Reiter, P Nov	A in its first phases: New insights in nuclear excitations along the nuclear 2021 PROGRESS IN PARTICLE AND NUCLEAR PHYSICS 121	chart Bracco, A;	 Gamma decay of pygmy in E. G. EP3A 51(2015)99. 	tates from invitatic scattering of lane, $Bracco, A$; Crespi, F. C	L; Lana,	20) "Measurement of 15 MeV (- Gades, D. Giugni, B. Herskind, M	ays with Ge cluster detectors of EUROMAL *B. Million, Jimlecik, R. Isocrate, S. Leoni, A. Maj, F. Preiz and O.	A. Bracco, F. Camera, S. Brambilla, A. Weland Nucl. Inst. Neth.
6) Reinterpretation of excited state A; (); A. Bracco, Valiente-Dob	es in 212Po: Shell-model multiplets rather than a cluster states, Fernánde on, JJ, Nov 29 2021 PHYSICAL BEVIEW C104	rz, A; Jungclaux,	13) Pygmy dipole resonance i L.; et al. PHYSICS LETTERS 8 (20	is Sn-124 populated by inelastic scattering of G-17, Pellegri, L 14) Volume: 738 Pages: 519-523	Bracco, A.; Compl., F. C.	A452(2000)422 20) "Unreadived general-rays in t Million, N. Basi, G. LoBianco, M.	14Te: mass dependence of rotational damping * 5. Fra Pignanelli, E. Vigezzi, B. Herskind, T. Doutina, H. Bere	tiol, A. Bracco, S. Leoni, F. Camera, B. trom, P. Varmette and S. Tormanen,
 γ decay to the ground state from Wasilewska, 8; Kmiecik, Ν; (); 	the excitations above the neutron threshold in the 208Pbg, $p^{-}\gamma\gamma$ reaction. A. Bracon, Lukasik, J. Jan 14 2022, PHYSICAL REVIEW C105(014210)	an at 85 MeV	14) Isospin Character of Low- Bracco, A.; Nicolini, R.; et al. PH	Lying Pygmy Dipole States in Pb-208 via Inelastic Scattering of C ISICAL REVIEW LETTERS (2014/Volume: 113 Iosae: 1 Ar	17 Ians, Crespi, F. C. L.; ticle Number: 012501	A. Naj, M.Kmiecik, D.R. Napoli a 21) Nuclear Structure of Finite T Amsterdam (1998), volume Auto	nd M. Natuus Phys. Rev. Lett. 83 (1999) 5234. Imperature P.F. Bortignon, A. Bracco and R.A. Broglia, collana Contemporary Concents in Physics.	Harwood Academic Publishers,
B) location and however option excitations: Native properties from how-line states and from the however glast dipole resonance lineace, Ac, Lance, and E. G.; Tami, A. PROGRES INVESTIGATION DEVICES FIRST SIGE 360-240 (2019) 9) Is exected by a partial dynamic symmetry in the first applicable Microalec. A. L: Banacol. G.; "Matanada, N.;		 Concluding remarks on the DMDD12 conference, Bracco, logisl HM 217 (2011) 217, 810. Excluding to the Deposite Nature of the Law-Energy gamma Enhancement in Fe-56, Lansen, A. C.; Blasi, N.; Bracco, A.; et al./HYSCAL. Interest Interface Lawson. 			 The Analysis of the Analysis of the Analysis of Phylics. The Analysis of the Analysi			
 n sensory a partial dynamic sys LETTERS & 781(2018)706. Observation of isoscalar an 	d however dipole excitations in neutron-rich 0-20, Nakatuka, N.: Baba, H.: And A. S. Sabatuka, N.: Baba, H.: And A. S. Saba, H.: And A. S. Sabatuka, N.: Sabatuka, Sabatuka, N.: Sabatuka,	mano, T.; A.	HENEW LEITERSTIT(2013), 242 1) "The Pygmy Dipole Resonance Vol. 66(2011)374	err . In 68N and the neutron skin", O. Wieland and A. Bracco, F	rogress in Particle and Naciesr Physics	11) * Possible Conservation of the T. Dosring, G.B. Hagemann, R. B	K-Quantum Number in Excited Rotating Nuclei' P. Bose ark, A. Brockstedt, P. Dotrom, H. Carlson, A. Nordiano	tti, S. Leoni, A. Bracco, B. Henkind, , H. Ryde, F. Camera, S. Fratzini, M.
Bracco et al. PHYSICS LETTERS 874 11) Acapin Mixing in 2r-80: Fra et al. DHYDC Mixing in 2r-80: Fra	sia (2017) 387. m Floble to Zero Temperature ,Cenuti, S.; Camera, F.; Bracco, A.; etc. 20193 20290		 "Constraints on the symmetry Cao, P. F. Bortigron, F. Camera a cit. Effective 	y energy and neutron skins (han pygny resonances in 4W and od O. Weland, Phys. Rev. C B1 (2010) 041301 (R)	"Sn" & Carbone, G. Colo, & Bracco, L.	Mattuzzo, u. Million, D. Bazzacco (1996)1204. 34) * Fluctuation Analysis of Anti-	e, e. eservit, L. de Angers, U. De Acuna, N. de Poli and stional Spectra." T. Dossing, B. Henkind, S. Leoni, M. H.	-, ramon, PTyt. MW, LHEL /6 atsuo, A. Bracco, R. A. Broglia, and E.
NAME AND ADDRESS OF A DESCRIPTION OF A D			re "vrozeng the nature of partic D.Mengoni, G.Benzoni, N.Blad, O.Weland, J.J.Vallente-Dobon, I R.Styretti, J. W Seducini, P. N.	arcure cosponge in 46.0 with y spectroscopy and heory-los to G.Bocchi, P.J.Bortignon, A.Bracco, F.Camera, G.Colo, A.C. Cornell, G.de Angelie, F.Della Vedova, E.Floretto, A.Gadea, I etc. S.Szilov, D.Bazzacco, E.Florma, D.Monaerre, A.C. Color, S. Station, C. Bazzacco, C.Florma, D.Monaerre, A.C. Color, S. Station, C. Bazzacco, C.Florma, D.Monaerre, A.C. Color, S. Station, C. Bazzacco, C.Florma, D. Monaerre, A.C. Color, S. Station, C. Bazzacco, C.Florma, D. Monaerre, A.C. Color, S. Station, C. Bazzacco, C. Florma, D. Monaerre, A.C. Color, S. Station, C. Bazzacco, C. Florma, D. Monaerre, A.C. Color, S. Station, C. Bazzacco, C. Station, S. Station, C. S. Station, C. Bazzacco, C. Florma, D. Monaerre, A.C. Station, C. Sta	seque relations", D.Nontanari, S.Leoni, anti, F.C.L.Creepi, B.Million, R.Nicolini, (R.Napoli, R.Orlandi, F.Recchia, E.Sahin, do, S.M.Lenzi, S.Lunardi, G.Nevenanoli	vigezzi, Phys. Report 268(1996)1 25) "Wicroscopic Simulations of go Dossing, B. Henskind, M. Natsuo, F	ww. mme-caucades in warm rotating nuclei", A. Bracco, P. Boset 91.76, (1996)4484.	i, S. Pratzini, E. Vigezzi, S. Leoni, T.
			F.Scartassara, C.Ur., G.Lo Bianco, (2011) 20) "Search for the Puerry Newle	A.Zucchiatti, M.Kmiecik, A.Maj, W.Meczynki, A.Dewald, Th.F Resonance in N-68 at 600 MeV/nucleon* - Weland: ** Reson	mata, G.Pollardo, Phys.Lett. 8 607, 288 , A; Camera, F; Berzoni, G; Bani, N	36 Thornesse of the width of the F. Camera, M.Mattiluzzi, B.Million 74(1995)2748.	Giant Dipole Resonance in hot Nuclei: Shape Change o , N. Pignanelli, J.J.Gaardhoje Z.Zelszny, T.Ramsoy, T.T	Collisional Damping 7" A.Bracco, reter and A. Haj Phys. Rev. Lett.
			Brambilla, S. Crespi, FCL; Leoni, Aumann, T. Banu, A; Beck, T; Bec Kojouharov, I; Kurz, N; Leonu, R	S; Million, B; Nicolini, R; Hay, A; Becharczyk, P; Grebouz, J; Kr ler, F; Cacerer, L; Doomenbal, P; Dming, H; Gerl, J; Gelael, H Salto, N; Salto, T; Schaffber, H; Wallenbeim, HJ; Jolie, J; Ref	lecik, M.; Neczynski, W.; Szyczen, J.; Gordu, H.; Kavatzysk, Q.; Kavatzysk, H.; er, P.; Warr, N.; destogelik, G.; Gadesa, A;	 Limiting Temperature for th Broglia, Phys. Rev. Lett. 67(1991) M. Lintering et al. 	e Existence of Collective Mation in Not Nuclei." P.F. B (3360)	rtigron, A. Bracco, D. Brink, and R. A.
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- President of the Italian Physics Society (SIF). (Bologna)
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- Chair of the Nuclear Physics Board of INFN (CSN3).
- MIUR (Ministry of Research and University) representative member in the Board of Directors of INFN.
- Chair of NuPECC.
- Chair and member of many scientific committee.
- Member of several international evaluation panels.
- Member of several Scientific Committees of Laboratories and Research Institutions.

Involved in the realisation of detection system for gamma-ray (EUROBALL, RISING and AGATA).

Co-Editor of European Physics Letters (EPS journal).
Supervisory Editor of Nuclear Physics A.

Author of more than 350 papers.

- 0 85 Invited talks.
- Referee of many papers in several scientific journals.

Giant Resonances: Nuclear Structure at Finite Temperature



P. F. Bortignon, Angela Bracco, R. A. Broglia

Harwood Academic Publishers, 1998 - 275 páginas

The series of volumes, Contemporary Concepts in Physics, is addressed to the professional physicist and to the serious graduate student of physics. The subject of many-body systems constitutes a central chapter in the study of quantum mechanics, with applications ranging from elementary particle and condensed matter physics to the behaviour of compact stellar objects. Quantal size effects is one of the most fascinating facets of many-body physics; this is testified to by the developments taking place in the study of metallic clusters, fullerenes, nanophase materials, and atomic nuclei. This book is divided into two main parts: the study of giant resonances based on the atomic nucleus ground state (zero temperature), and the study of the y-decay of giant resonances from compound (finite temperature) nuclei.

« Menos

Her first paper (according to INSPIRE)

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PHYSICAL REVIEW LETTERS

30 May 1983

Study of Two-Nucleon Wave Functions in ³He

A. Bracco^(a), H. P. Gubler^(a), D. K. Hasell^(a), and W. T. H. van Oers^(a) University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

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Nuclear Physics A482 (1988) 421c-436c North-Holland, Amsterdam

GIANT RESONANCE EXCITATION IN HEAVY ION COLLISIONS. PROCEEDINGS, 1ST TOPICAL MEETING, LEGNARO, ITALY, SEPTEMBER 21-25, 1987

P.F. Bortignon(ed.), J.J. Gaardhoje(ed.), M. Di Toro(ed.) 1988

The Direct Neutron Decay of Giant Resonances in ²⁰⁸Pb

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PHYSICAL REVIEW LETTERS

28 September 1987

Limits of Collective Motion in Hot Nuclear Matter

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PHYSICAL REVIEW LETTERS

1 May 1989

Saturation of the Width of the Giant Dipole Resonance at High Temperature

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... to make the long story short ... after hundreds of papers ...

Search for the Pygmy Dipole Resonance in ⁶⁸Ni at 600 MeV/nucleon

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8th Japan - Italy Symposium RIKEN 7 - 10 March 2016







The Pygmy Dipole Resonances (PDR) are dipole states located at much lower energy than the GDR peak.

They were called "pygmy" because their strength are much smaller than GDR.

They exhaust only few per cent of the IVEWSR.

They are present in all the nuclei with neutron excess. Therefore, they should be more evident in nuclei far from the stability line

> ¹³²Sn + ²⁰⁸Pb @ 500 MeV/u P.Adrich et al., PRL 95 (2005) 1.32501



Pygmy Dipole Resonance Experimental data

68NL

ABOVE NEUTRON SEPARATION THRESHOLD exotic nuclei

using the FRS-LAND setup at GSI
 using the RISING setup at GSI (for ⁶⁸Ni)

P.Adrich et al. PRL 95 (2005) 132501 O.Wieland et al. PRL 102 (2009) 092502





BELOW NEUTRON SEPARATION THRESHOLD stable nuclei

with (γ,γ') studies (Darmstadt University)
 with (α,α'γ) at KVI.
 with (¹⁷0,¹⁷0'γ) at LNL

D.Savran et al. PRL 100 (2008) 232501 J.Endres et al. PRC 80 (2009) 034302 F.C.L.Crespi et al. PRL113(2014)012501



It is well established that the low-lying dipole states (the Pygmy Dipole Resonance) have a strong isoscalar component.



Neutron and Proton transition densities are in phase inside the nucleus;

at the surface only the neutron part contribute.

"Theoretical definition" of the PDR It is possible to study these states also via an isoscalar probe

Splitting of the low-lying dipole strength

with (α,α'γ) at KVI.
 with (¹⁷0, ¹⁷0' γ) at LNL

D. Savran et al., PRL 97 (2006)172502 J. Endres et al., PRC 80 (2009) 034302 J. Enders et al., PRL 105 (2010) 212503 F.C.L. Crespi et al. PRL 113 (2014) 012501



By using different reactions employing electromagnetic and hadronic probes of different types (like a-particle, ¹⁷0, ¹²C and p) one is expected to be sensitive to different regions on the nuclear volume and thus the comparison of the results provides indication on the nature of these states

In these cases also the inelastic cross section is measured and therefore it is of paramount importance to calculate it

In the experimental analysis, for these cases, a fundamental role is played by the radial form factors used

The description of inelastic cross section with isoscalar probes
– DWBA, first order theory
– Coupled Channel, high order effect important

- Semiclassical approximations Example: the transition amplitude for the DWBA

$$T^{DWBA} = \int \chi^{(-)}(k_{\beta}, r) F(r) \chi^{(+)}(k_{\alpha}, r) dr$$

the radial form factor F(r) contains all the structure properties, they can be derived in macroscopic or microscopic approaches

$$F^C(r) \approx \frac{\sqrt{B(EL)}}{r^{L+1}}$$

$$F^N(r) \approx \beta_N \frac{dU^N(r)}{dr}$$

For the dipole radial form factors calculation one needs the radial transition densities

• Goldhaber-Teller for the IVG-DR $\delta \rho^{GT}(r) = \beta_1 \left[\frac{2N}{A} \frac{d}{dr} \rho_p(r) - \frac{2Z}{A} \frac{d}{dr} \rho_n(r) \right]$

 $\delta \mu rakeh-Dieperink for the ISGDR$ $\delta \rho^{HD}(r) = -\frac{\beta_1}{R\sqrt{3}} \left[3r^2 \frac{d}{dr} + 10r - \frac{5}{3} < r^2 > \frac{d}{dr} + \epsilon \left(r\frac{d^2}{dr^2} + 4\frac{d}{dr}\right) \right] \rho_0(r)$

 Microscopic transition densities (RPA or more sofphisticated approaches) The nucleon nucleon interaction depends on the isospin

 $\nu_{12} = \nu_0(r_{12}) + \nu_1(r_{12})\tau_1 \cdot \tau_2$ where τ_i are the isospin of the nucleons.

In the case $\rho_n = N/Z \rho$; $\rho_p = N/A \rho$, F_1 is zero when one of the two nuclei has N=Z.

Double Folding procedure



The nuclear form factors are

$$F_{0}(r_{\alpha}) = \iint [\delta \rho_{A_{n}}(\vec{r}_{1}) + \delta \rho_{A_{p}}(\vec{r}_{1})] \nu_{0}(r_{12}) [\rho_{a_{n}}(\vec{r}_{2}) + \rho_{a_{p}}(\vec{r}_{2})] r_{1}^{2} dr_{1} r_{2}^{2} dr_{2}$$

$$F_{1}(r_{\alpha}) = \iint [\delta \rho_{A_{n}}(\vec{r}_{1}) - \delta \rho_{A_{p}}(\vec{r}_{1})] \nu_{1}(r_{12}) [\rho_{a_{n}}(\vec{r}_{2}) - \rho_{a_{p}}(\vec{r}_{2})] r_{1}^{2} dr_{1} r_{2}^{2} dr_{2}$$

Folding done with the effective nucleon-nucleon M3Y interaction and with the RPA transition densities



The Coulomb contribution is very different for the two states, while the nuclear one is of the same order of magnitude.

Since the PDR are non collective, one cannot employ standard codes which make use of macroscopic form factors.

The nuclear and Coulomb parts interfere destructively at small radii and constructively at large radii. This is mainly due to isoscalar part and to the fact that the isoscalar dipole transition density displays nodes

In the semiclassical model the two nuclei move according to a classical trajectory while quantum mechanics is used to describe the internal degrees of freedom $H = H_A + H_B$ $H_A = H_A^0 + W_A(t)$ where $W_{A}(t) = \sum \langle i | U_{B}(\vec{R}(t)) | j \rangle a_{i}^{+} a_{i} + hc.$ t-dependence through R(t) $|\Psi,t\rangle = \sum A_{\alpha}(t)e^{-iE_{\alpha}t}|\Phi_{\alpha}\rangle$ The time dependent state is The Schrödinger equation can be cast into a set of coupled linear differential equations $\dot{A}_{\alpha}(t) = -i\sum e^{i(E_{\alpha} - E_{\alpha'})t} < \Phi_{\alpha}|W(t)|\Phi_{\alpha'} > A_{\alpha'}(t)$ Probability to excite the state a as function of $P_{\alpha}(b) = |A_{\alpha}(t=\infty)|^2$ the impact parameter b $\sigma_{\alpha} = 2\pi \int_{0}^{1+\infty} P_{\alpha}(b)T(b)b \, db.$ and its cross section is T(b) the transmission coefficient





Angela and her group started a campaign, at Laboratorio Nazionale di Legnaro, to investigate the structure of Pygmy resonances states. with an isoscalar probe.

A number of measurements were done using the (170,170' V) reaction at a bombarding energy of about 20 MeV/u. The ²⁰⁸Pb, ¹²⁴Sn and ⁹⁰Zr and ¹⁴⁰Ce nuclei were studied with this reaction.



Fig. 10. Schematic representation of the experimental setup including segmented silicon detectors placed at forward angles and the AGATA HPGe detectors. The angle $\theta_{\gamma,\text{recoil}}$ between the direction of the recoiling ²⁰⁸Pb ions (dashed line) and of the gamma-ray (when a scattered ¹⁷O is detected in the right silicon telescope) is displayed.

The analyses of the differential cross sections were performed within the framework of the Distorted Wave Born Approximation (DWBA).

F.C.L. Crespi et al., PRL 113 (2014) 012501



208Pb(170,170y)208Pb at 340 MeV

Using TRACE prototype and AGATA Demonstrator system

DWBA calculations (with FRESCO) using the microscopic form factors shown before



L. Pellegri et al., PLB 738 (2014) 519

124 Sn(170, 170)124 Sn at 340 MeV





F.C.L. Crespi et al., PRC 91 (2015) 024323





M. Krzysiek et al., PRC 93 (2016) 044330

14°Ce(170,170Y)14°Ce

at 340 MeV





Experimental data isoscalar probe (below neutron emission threshold) The use of isoscalar probes has brought to light a new feature of this new mode

The splitting of the PDR

D. Savran et al., PRL 97 (2006) 172502
J. Endres et al., PRL 80(2009) 034302
J. Endres et al., PRL 105 (2010) 212503
F.C.L. Crespi et al., PRL 113 (2014) 012501
L. Pellegri et al., PLB 738 (2014) 519
F.C.L. Crespi et al., PRC 91 (2015) 024323



F.C.L. Crespi, et al., PLB 816 (2021) 136210

The 90,94Zr nuclei investigated via $(p, p'\gamma)$ at 80 MeV and $(\alpha, \alpha'\gamma)$ at 130 MeV. At RCNP, with the magnetic spectrometer Grand Raiden for the scattered particles and the array CAGRA with HPGe detectors for the γ -decay.

The E1 ISEWSR strengths of the states were extracted from the data by DWBA calculations performed for the $(\alpha, \alpha'\gamma)$ reaction.

Under the assumption that the information extracted with the $(\alpha, \alpha'\gamma)$ can be extended to the (p, p') reactions, the calculations for the cross section for the reaction $(p, p'\gamma)$ have been done with the values of the ISEWSR obtained from the α reaction.

The general trend have been reproduced except for few states for the ⁹⁰Zr case. It is worthwhile to apply this analysis – improving the modelling – to other nuclei, to try to understand better the intrinsic structure of these low-lying dipole states.



Some Open Problems: 1. Are the dipole resonances due to collective or single-particle excitations? 2. Spherical and Deformed nuclei 3. What is the interplay between isovector and isoscalar contributions?

Progress in Particle and Nuclear Physics 106 (2019) 360–433	Screit Hultuna di Fisica	2 Springer
Gamma decay of pygmy states from inelastic scattering of ions A. Bracco ^{1,2,a} , F.C.L. Crespi ^{1,2} , and E.G. Lanza ³ ¹ Dipartimento di Fisica dell'Università degli Studi di Milano, I-20133 Milano, Italy ² INFN, Sezione di Milano, I-20133 Milano, Italy ³ INFN, Sezione di Catania, I-95123 Catania, Italy		From: Gamma decay of pygmy states from inelastic scattering of ions by A. Bracco et al.
Eur. Phys. J. A (2015) 51 : 99 DOI 10.1140/epja/i2015-15099-6 THE EUROPEAN PHYSICAL JOURNAL A Review	EPJA Recognized by European Physical Society	Hadrons and Nuclei
	The European Physical Journal	volume 51 · number 8 · august · 2015

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Review

Isoscalar and isovector dipole excitations: Nuclear properties from low-lying states and from the isovector giant dipole resonance



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 ^d Research Center for Nuclear Physics, Osaka University, Japan

A. Bracco, E.G. Lanza, A. Tamii, Prog. Part. Nucl. Phys. 106 (2019) 360.







The title of my abstract was

The Pygmy Dipole Resonances or "The isoscalar pleasure to collaborate with Angela"



But this is not the end

SYMPOSIUM on Resonances and related topics

for Angela Bracco University retirement

Dear Angela, congratulation for your past achievements and best wishes for the future ones!!

Thank you for your attention