Structure of light exotic nuclei and halo nuclei

Poland: Krzysztof Rusek, Giulia Colucci, (Łukasz Standyło), Heavy Ion Laboratory, University of Warsaw
Nicholas Keeley, National Centre for Nuclear Research, Świerk

France: Alain Gillibert (Valerie Lapoux), Damien Thisse, Nicolas Alamanos, CEA Saclay DRF Irfu DPhN
Freddy Flavigny, LPC Caen

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Mirror nucleon-transfer reactions from ^{18}Ne and ^{18}O

F. Flavigny,[1] N. Keeley,[2] A. Gillibert,[3] V. Lapoux,[3] A. Lemasson,[4] L. Audirac,[3] B. Bastin,[4] S. Boissinot,[3] J. Caccitti,[4] A. Corsi,[3] S. Damoy,[4] S. Franchoo,[5] P. Gangnant,[4] J. Gibelin,[1] J. Goupil,[4] F. Hammache,[5] C. Houarner,[4] B. Jacquot,[4] G. Lebertre,[4] L. Legeard,[4] L. Ménager,[4] V. Morel,[4] P. Morfouace,[5,6] J. Pancin,[4] E. C. Pollacco,[3] M. Rejmund,[4] T. Roger,[4] F. Saillant,[4] and M. Sénoville[3]

[1]*Université de Caen Normandie, ENSICAEN, CNRS/IN2P3, LPC Caen UMR6534, F-14000 Caen, France*
[2]*National Centre for Nuclear Research, ul. Andrzeja Sołtana 7, 05-400 Otwock, Poland*
[3]*Université Paris-Saclay, IRFU, CEA, F-91191 Gif-sur-Yvette, France*
[4]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DRF-CNRS/IN2P3, Boulevard Henri Becquerel, F-14076 Caen, France*
[5]*Université Paris-Saclay, CNRS, IJCLab, F-91405 Orsay, France*
[6]*CEA, DAM, DIF, F-91297 Arpajon, France*

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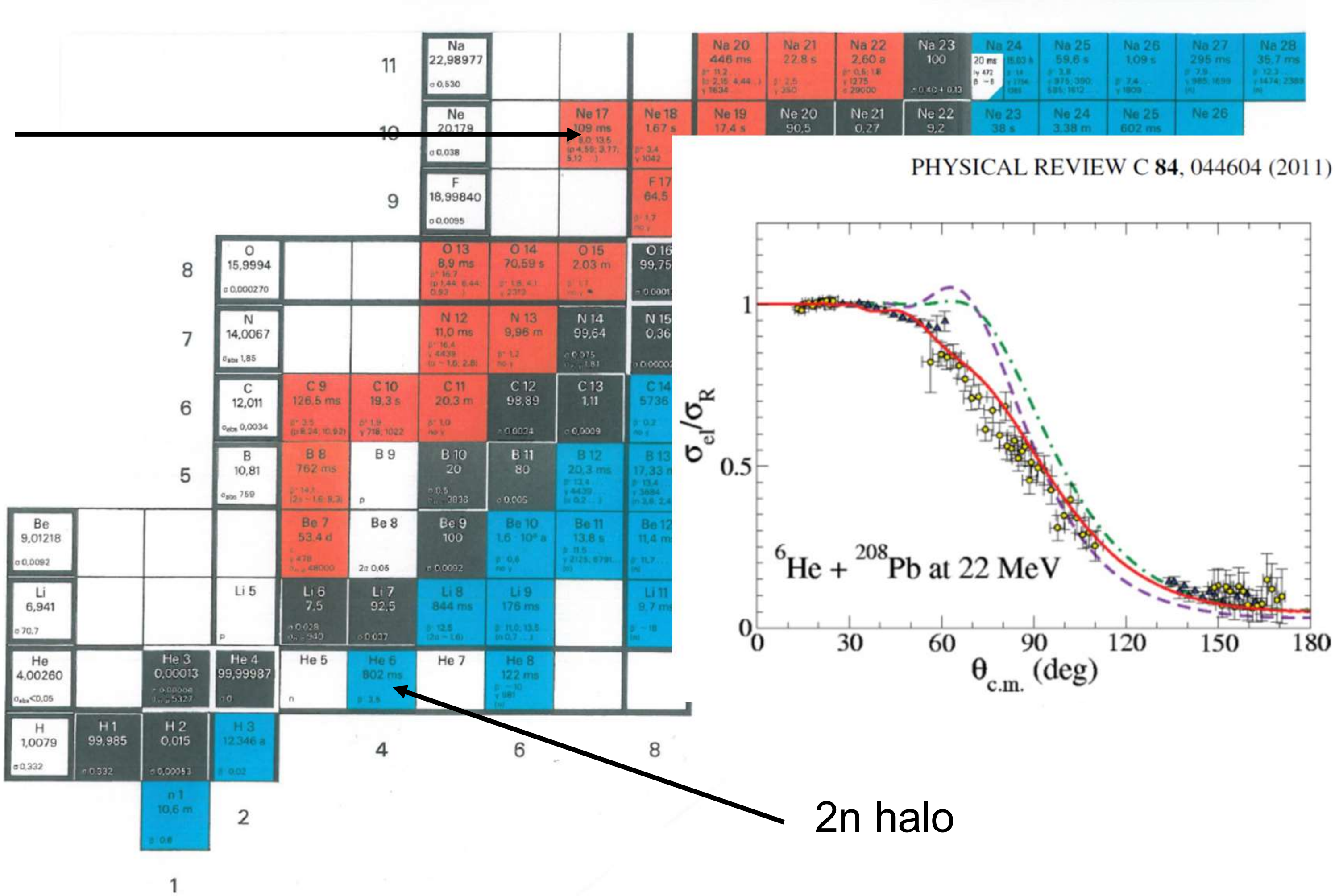
The ^{18}Ne$(d,t)^{17}$Ne and ^{18}Ne$(d,{}^{3}$He$)^{17}$F single-nucleon pickup reactions were measured at 16.5 MeV/nucleon in inverse kinematics together with elastic and inelastic scattering channels. The full set of measured exclusive differential cross sections was compared with the mirror reaction channels on stable ^{18}O after consistent reanalysis using coupled reaction channels calculations. Within this interpretation scheme, most of the spectroscopic factors extracted for the population of unbound states in ^{17}F match within uncertainties with their mirror partners in ^{17}O. However, for the deeply bound neutron removal channel to ^{17}Ne, a significant symmetry breaking with the mirror proton-removal channel leading to ^{17}N is evidenced by an overall single-particle strength reduction.

					HFB constrained r_0	
Beam	Reaction	Residue	E (MeV)	J^π	r_0 (fm)	C^2S_{exp}
^{18}Ne	(d,t)	^{17}Ne	0.0	$1/2^-$	1.480	0.72(9)
			1.288	$3/2^-$	1.326	0.22(3)
^{18}O	$(d,{}^3\text{He})$	^{17}N	0.0	$1/2^-$	1.465	1.15(16)
			1.374	$3/2^-$	1.311	0.37(6)
^{18}Ne	$(d,{}^3\text{He})$	^{17}F	0.0	$5/2^+$	1.244	1.04(10)
			0.495	$1/2^+$	1.108	0.14(1)
			3.104	$1/2^-$	1.214	0.55(5)
^{18}O	(d,t)	^{17}O	0.0	$5/2^+$	1.272	1.04(12)
			0.871	$1/2^+$	1.210	0.08(1)
			3.055	$1/2^-$	1.267	0.61(6)

Two-proton halo structure of ^{17}Ne

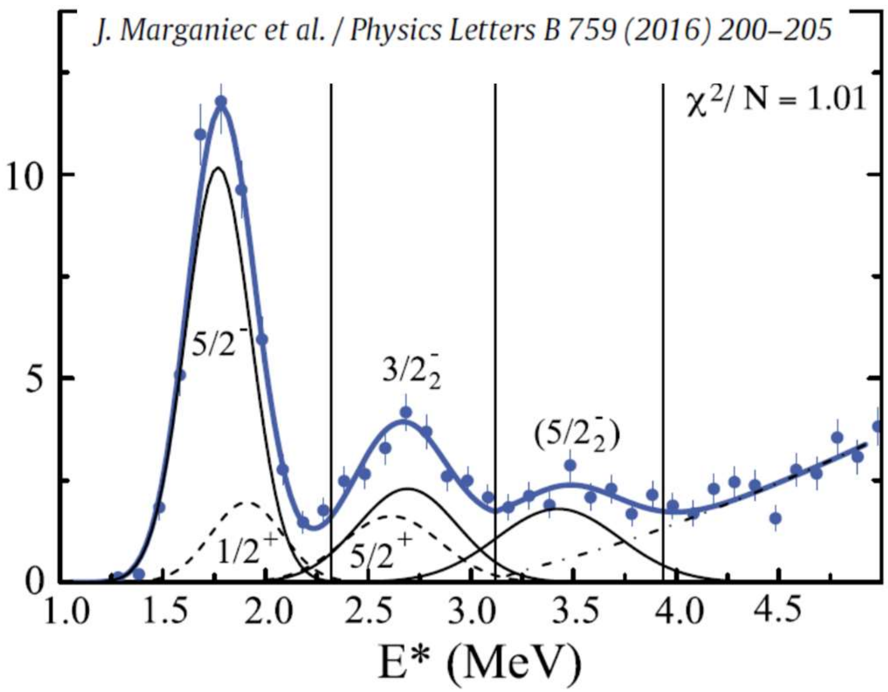
GANIL: A. Chbihi, N. Goyal, A.K. Orduz, A. Ortiz,

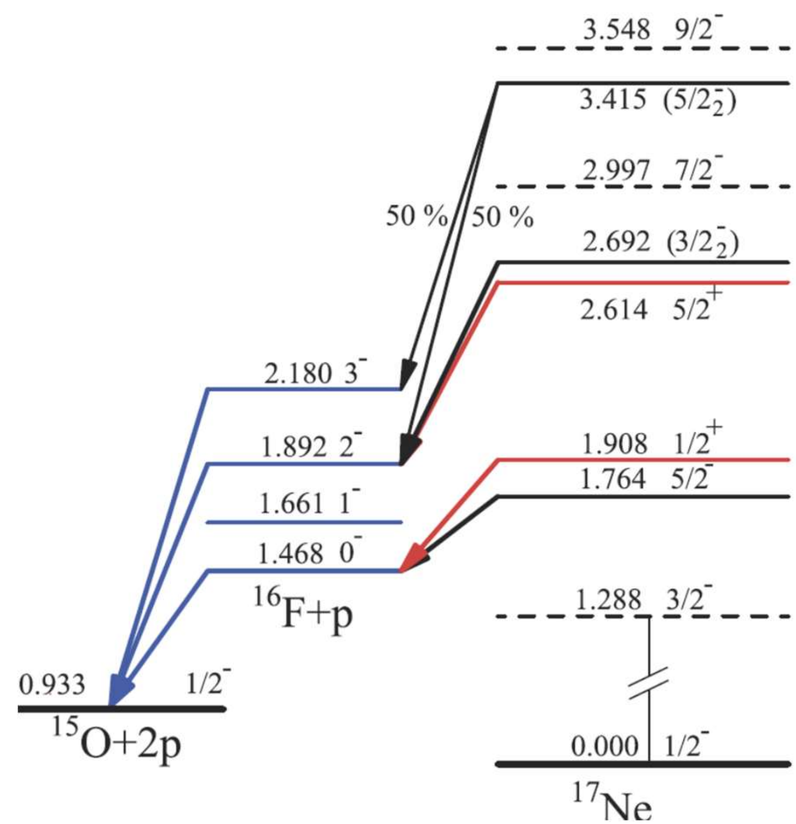
2p halo?



2n halo

From Coulomb exc. exp. at GSI





I^π	E^*	σ_C	$\pi\lambda$	$N(\pi\lambda)$	$B(\pi\lambda)$
$5/2^-$	1.764	7.13(1.5)	$E2$	11868	90(18)
$1/2^+$	1.908	<2.4	$E1$	121.43	<0.007
$(3/2_2^-)$	2.692	5.57(76)	$E2$	5180.4	69(10)
$(3/2^+)$	5.141	13.6(1.7)	$E1$	68.68	0.071(9)
$5/2^-$	1.764	29.9(4.4)	$E2$	24990	179(26)

From Chromik et al. PRC 66, 024313 (2002)

$T_{1/2}$=109.1 ms

Experiment at GANIL

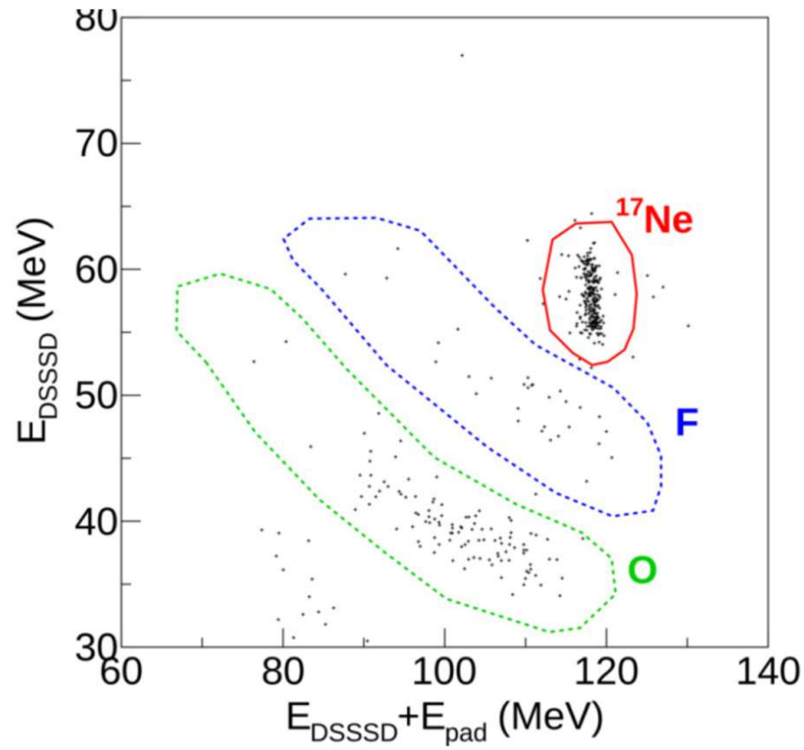
SPIRAL 1 facility, fragmentation of ^{20}Ne beam on graphite target, postacceleration by CIME cyclotron to 136 MeV, intensity 1.5x10^4 p/s

Great support from co-authors: A. Chbihi, N. Goyal, A.K. Orduz, A. Ortiz,

GLORIA detection system (I. Martel, Univ. of Huelva)

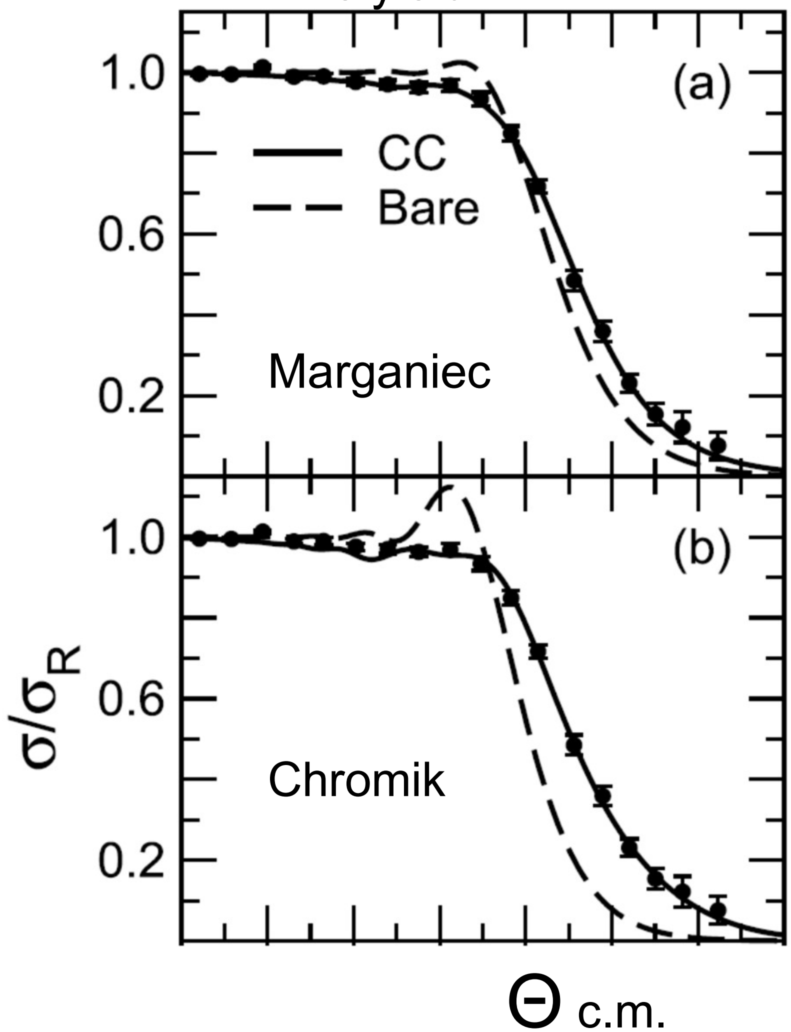
Target 1.2 mg/cm^2 sef supporting ^{208}Pb foil

Detected fragments:



Results

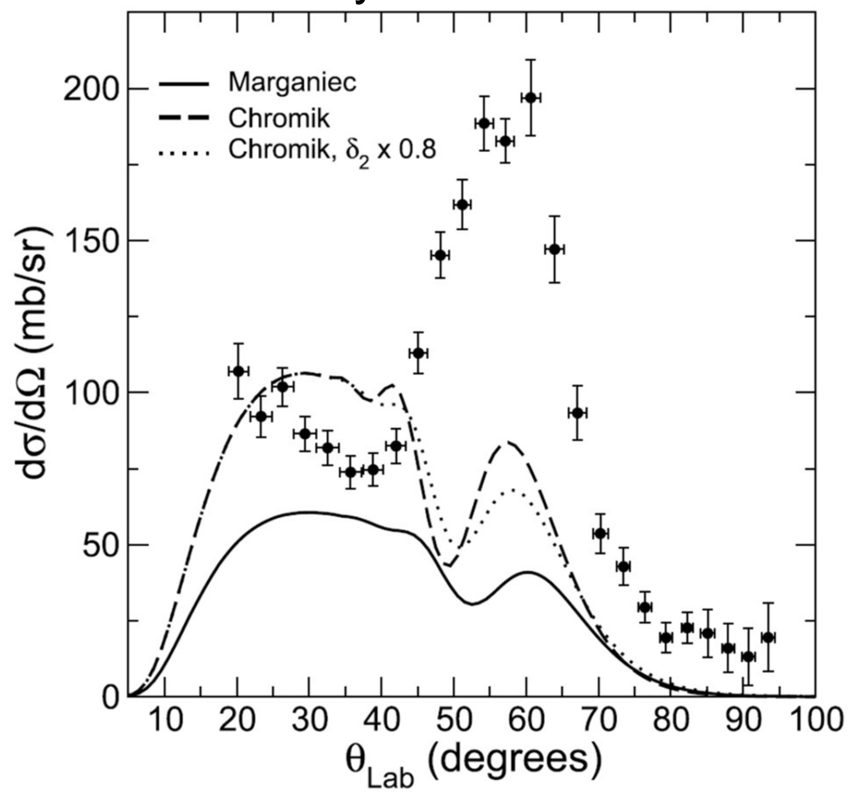
El. ^{17}Ne yield



Similar to ^{6}He → 2p halo

Where ^{15}O is coming from?

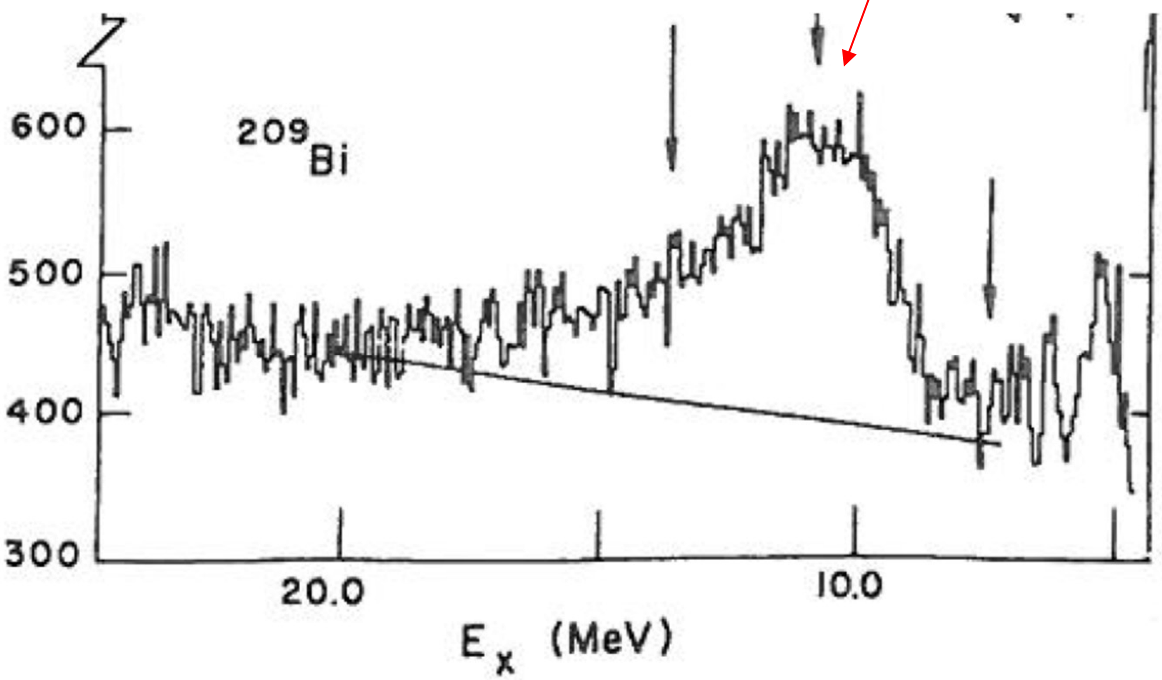
Inel. ^{15}O yield



Solid curves – calculations included L=2 coupling to 3/2- and 5/2- resonances

^{15}O yield

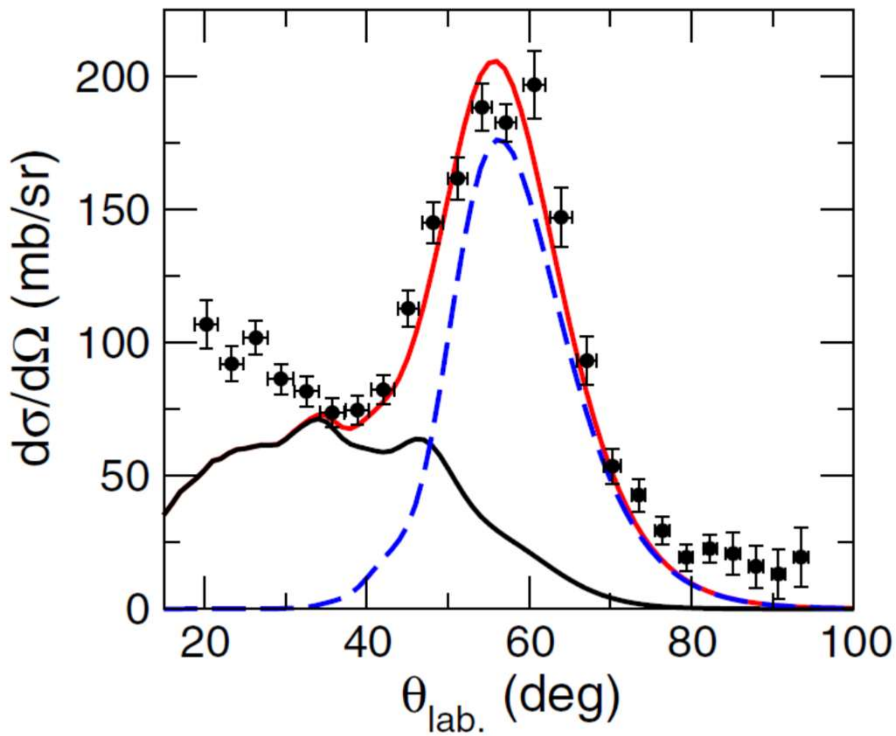
Hypotesis: $^{208}Pb(^{17}Ne,^{16}F)^{209}Bi^*$ (GQR)



^{209}Bi	
E_x (MeV)	Γ (MeV)
10.9 ± 0.3	2.7 ± 0.3
13.7 ± 0.3	2.0 ± 0.4

M.N. Harakeh et al. NPA 327 (1979) 373, alpha scattering from ^{209}Bi

Bingo!



^{15}O yield

Black solid curve – inelastic exc. of ^{17}Ne
Blue dahed curve – 1p transfer
Solid red curve - sum

Summary

- Coulomb excitation exp. of ^{17}Ne needed (Marganiec, Chromik or….?)

- Experiments with ^{15}O beam would help

- Contribution of transfer reactions can compete with breakup!

- 2p structure of ^{17}Ne confirmed

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Suppression of Coulomb-nuclear interference in the near-barrier elastic scattering of ^{17}Ne from ^{208}Pb

J. Díaz-Ovejas [a], I. Martel [b,*], D. Dell'Aquila [c,q], L. Acosta [e], J.L. Aguado [b], G. de Angelis [f], M.J.G. Borge [a], J.A. Briz [a], A. Chbihi [g], G. Colucci [h], C. Díaz-Martín [b], P. Figuera [d], D. Galaviz [i], C. García-Ramos [b], J.A. Gómez-Galán [b], C.A. Gonzales [b], N. Goyal [g], N. Keeley [j], K.W. Kemper [k], T. Kurtukian Nieto [l], D.J. Malenica [m], M. Mazzocco [n,o], D. Nurkić [p], A.K. Orduz [g], A. Ortiz [g], L. Palada [m], C. Parascandolo [q], A. Di Pietro [d], A.M. Rodriguez [b], K. Rusek [h], F. Salguero [b], A.M. Sánchez-Benítez [r], M. Sánchez-Raya [b], J. Sánchez-Segovia [b], N. Soić [m], F. Soramel [n,o], M. Stanoiu [s], O. Tengblad [a], N. Vukman [m], M. Xarepe [i]

[a] Instituto de Estructura de la Materia, CSIC, 28006 Madrid, Spain
[b] Science and Technology Research Centre, University of Huelva, 21071 Huelva, Spain
[c] Dipartimento di Fisica Ettore Pancini, University of Naples Federico II, Naples, Italy
[d] INFN-Laboratori Nazionali del Sud, 95123 Catania, Italy
[e] Instituto de Física, UNAM, Mexico
[f] INFN-National Laboratories of Legnaro, 35020 Legnaro (PD), Italy
[g] Grand Accélérateur National d'Ions Lourds, BP 55027 - 14076 Caen, Cedex 05, France
[h] Heavy Ion Laboratory, University of Warsaw, ul. Pasteura 5a, 02-093 Warsaw, Poland
[i] LIP, Lisboa, Portugal
[j] National Centre for Nuclear Research, ul. Andrzeja Sołtana 7, 05-400 Otwock, Poland
[k] Department of Physics, The Florida State University, Tallahassee, FL 32306, USA
[l] Centre d'Etudes Nucléaires de Bordeaux Gradignan, Chemin du Solarium, Gradignan F-33175, Franc
[m] Rudjer Bošković Institute, Bijenička cesta 54, HR-10000 Zagreb, Croatia
[n] Dipartimento di Fisica e Astronomia, Università di Padova, via F. Marzolo 8, I-35131 Padova, Italy
[o] INFN-Sezione di Padova, via F. Marzolo 8, I-35131 Padova, Italy
[p] Department of Physics, Faculty of Science, University of Zagreb, Zagreb, Croatia
[q] INFN-Naples, Italy
[r] Centro de Estudios Avanzados en Física, Matemáticas y Computación, University of Huelva, 21071 H
[s] IFIN-HH PO-BOX MG-6, 76900 Bucharest Magurele, Romania

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Breakup and transfer reactions in the ^{17}Ne + ^{208}Pb system close to the Coulomb barrier

N. Keeley,[1,*] I. Martel,[2] K. W. Kemper,[3] and K. Rusek[4]

[1] *National Centre for Nuclear Research, ul. Andrzeja Sołtana 7, 05-400 Otwock, Poland*
[2] *Science and Technology Research Centre, University of Huelva, 21071 Huelva, Spain*
[3] *Department of Physics, The Florida State University, Tallahassee, Florida 32306, USA*
[4] *Heavy Ion Laboratory, University of Warsaw, ul. Pasteura 5a, 02-093 Warsaw, Poland*

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Our data are attractive for theorists!

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Suppression of the elastic scattering cross section for the $^{17}Ne + ^{208}Pb$ system

Kyoungsu Heo and Myung-Ki Cheoun
Department of Physics and Origin of Matter and Evolution of Galaxies (OMEG) Institute, Soongsil University, Seoul 06978, Korea

Ki-Seok Choi and K. S. Kim
School of Liberal Arts and Science, Korea Aerospace University, Koyang 10540, Korea

W. Y. So*
Department of Radiological Science, Kangwon National University at Dogye, Samcheok 25945, Korea

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Future - proposal E886_23

Probing the scattering of $^{17}Ne + ^{64}Zn$ at Coulomb barrier energies

I. Martel[1], K. Rusek[2], N. Keeley[3], A. Chbihi[4], L. Acosta[10,17], J.L. Aguado[1], C. Borcea[18], M.J.G. Borge[17], J. A. Briz[17], J. Cederkall[9], G. Colucci[2], G. de Angelis[20], D. Dell'Aquila[23], C. Díaz-Martín[1], C.A. Gonzalez-Cordero[1], A. Di Pietro[7], P. Figuera[7], C. García- Ramos[1], J.A. Gómez-Galán[1], D. Gupta[21], K. Kemper[22], T. Kurtukian-Nieto[17], M. Mazzocco[11], A. Pakou[5], S. Pandit[14], V. Parkar[14], R. Raabe[8], F. Salguero[1], A.M. Sánchez-Benítez[15], M. Sánchez-Raya[1], J. Sánchez-Segovia[1], F. Soramel[11], N. Soic[19], M. Stanoiu[18], O. Tengblad[17], R. Wolski[16], ...

Spokesperson(s): I. Martel(imartel@uhu.es) and N. Keeley (nicholas.keeley@ncbj.gov.pl).

GANIL contact person: A. Chbihi (abdelouahad.chbihi@ganil.fr)

Abstract

The reaction $^{17}Ne + ^{208}Pb$ at E_{lab}= 136 MeV was recently investigated by our collaboration at the SPIRAL1 facility in GANIL. The GLORIA detector system allowed to measure the angular distributions of the elastic scattering and inclusive ^{15}O production for the first time, unveiling unique features of proton halo dynamics at energies around the Coulomb barrier. The aim of this proposal is to investigate the competition between the break-up and proton-transfer in the Coulomb barrier scattering of ^{17}Ne on the medium-mass ^{64}Zn target, where the importance of the Coulomb field is reduced from that of the heavy targets. The new data will help to disentangle the coupling effects found with heavy targets and impose constraints on the values of the B(E2; 1/2−1 → 5/2−1).

Future – proposal at HIL

Proposal to the HIL Programme Advisory Committee

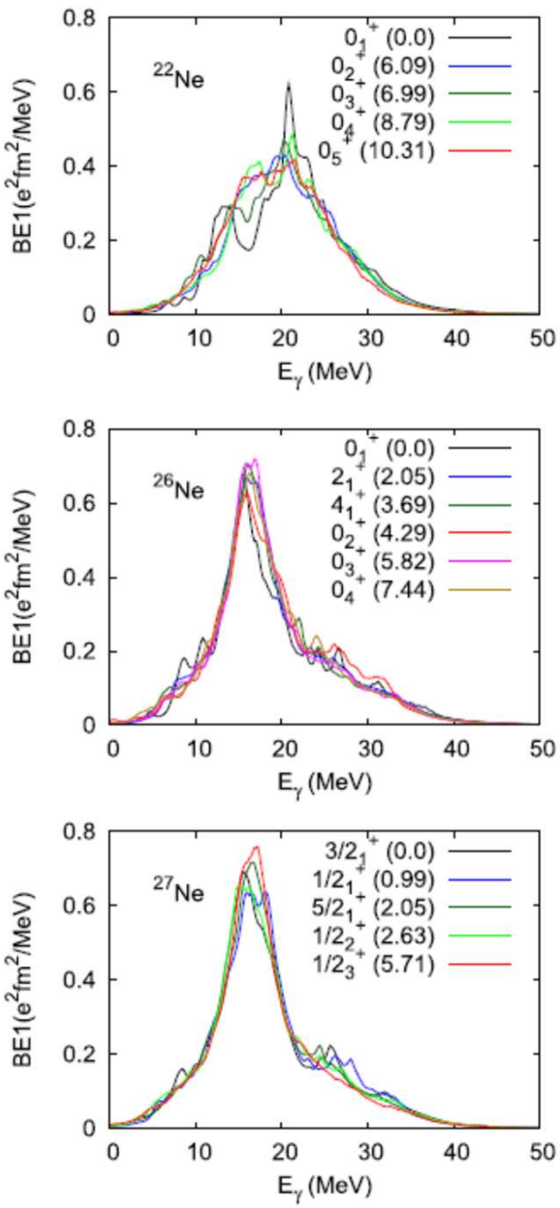
Study of ^{20}Ne Coulomb scattering with a ^{64}Zn target using the GLObal Reaction Ion Array –GLORIA

I. Martel[1], N. Keeley[2], K. Rusek[3], G. Kirby[4], R. Berjillos[1], G. Colucci[3], D. Gómez-Domínguez[1], C. García-Ramos[1], C.A. González-Cordero[1], J.A. Gómez-Galán[1], A. M. Sánchez-Benítez[1], M. Sánchez-Raya[1], J. Sánchez-Segovia[1], L. Standylo[3], F. Torabi[1], A. Trzcinska[3], M. Wolinska-Cichocka[3]

[1] *University of Huelva, 21071 Huelva, Spain*
[2] *National Centre for Nuclear Research, 05-400 Otwock, Poland*
[3] *Heavy Ion Laboratory, University of Warsaw, 02-093, Poland*
[4] *The Florida State University, Tallahassee, FL 32306 Florida, USA*

Spokesperson(s): I. Martel [imartel@uhu.es], N. Keeley [nicholas.keeley@ncbj.gov.pl]

Future – collaboraton with Kamila Sieja



Calculated dipole strengh distribution

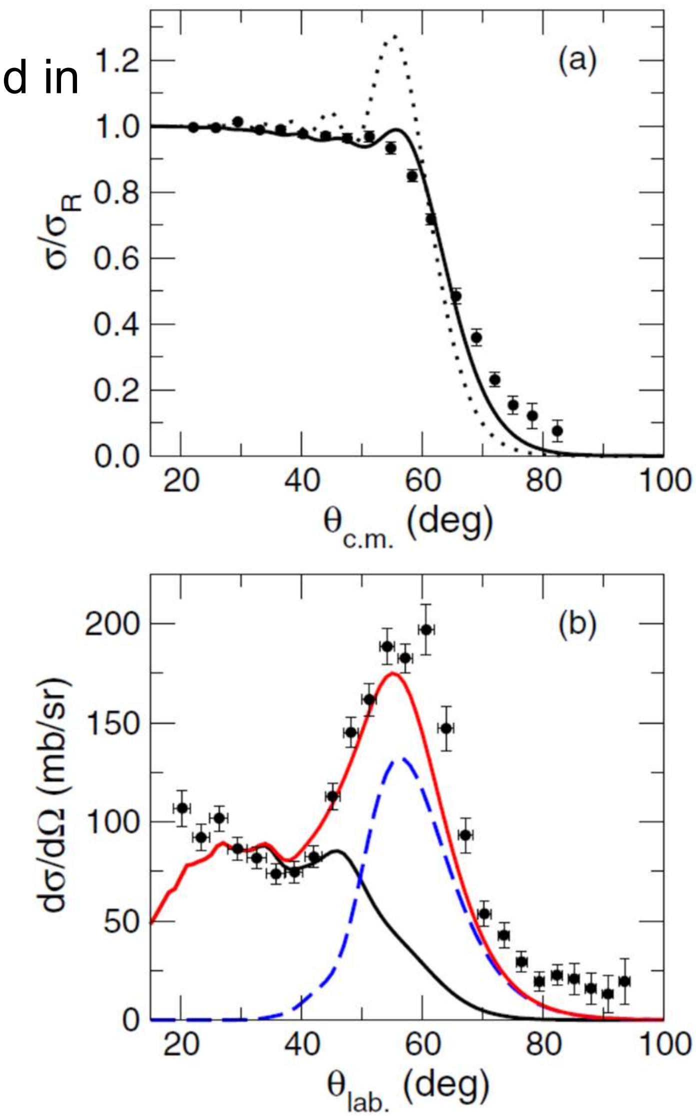
EPJA 59:147 (2023)

Thank you!

Two-proton halo structure of ^{17}Ne

Studied at SPIRAL 1:

^{17}Ne+^{208}Pb el. scattering (Fig. a),
^{17}Ne+^{208}Pb→ (^{15}O+*2p*)+^{208}Pb (inclusive ^{15}O yield in Fig. b)



Conclusions:

Elastic scattering shows similarities with ^{6}He el. scattering, supporting the *2p*-halo structure.

B(E2;1/2^{-}→5/2^{-} value of Marganiec et al. PLB 759, 200 (2016) better fits the data than that of Chromik, PRC 66, 024313 (2002).

^{15}O yield suggests a large contribution from stripping to the giant resonance in ^{209}Bi at an excitation energy of about 11 MeV

Papers:

J. Diaz-Ovejas et al. PLB 843, (2023) 138007
N. Keeley et al., PRC 108, 044603 (2023)