

# Wouter Ryssens

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## Research interests

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My goal is to understand **atomic nuclei**, furthering the description of the detailed structure of individual isotopes combined global structure across the nuclear chart. Often, I rely on **energy density functional theory** and the notion of spontaneous **symmetry breaking**, though I have experience with configuration-interaction approaches as well. My chief aim is the improvement of nuclear structure models for **extrapolation to the unknown regions** of the nuclear chart. In support of this goal, I actively develop new algorithms of various kinds to leverage modern computation.

**Keywords:** Energy density functionals, spontaneous symmetry breaking, mean-field approach, mass models, nuclear deformation, nuclear fission, nuclear level densities, quantum many-body problem, high performance computing, optimization algorithms.

## Experience

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### FNRS Postdoctoral Fellow

*Brussels, Belgium*

INSTITUT D'ASTRONOMIE ET D'ASTROPHYSIQUE, UNIVERSITÉ LIBRE DE BRUXELLES

*Oct. 2020 - PRESENT*

SUBJECT: PROVIDING INPUT FOR R-PROCESS CALCULATIONS: CONSTRUCTION OF LARGE-SCALE MASS MODELS

- Construction of the first mass model based on 3D DFT calculations using machine learning techniques
- Quantification of the impact of simultaneous triaxial and octupole deformation on fission barriers
- Calculation of fission barriers for odd-mass and odd-odd nuclei, without simplifying assumptions
- Development of algorithms for reliable convergence of calculations for odd-mass and odd-odd nuclei

### Postdoctoral Associate

*New Haven, CT, USA*

ALHASSID GROUP, YALE UNIVERSITY

*Sept. 2018 - Sept. 2020*

SUBJECT: STATISTICAL APPROACHES TO NUCLEAR LEVEL DENSITIES FOR NUCLEAR APPLICATIONS

- Development of HF-SHELL v1: mean-field calculations for deformed nuclei at finite temperature
- Development of HF-SHELL v2: QRPA calculations for deformed nuclei at finite temperature
- Comparison of exact calculations of nuclear level densities through Monte Carlo methods with mean-field approaches
- Development of new effective interaction for Monte Carlo calculations in the configuration interaction shell model

### Postdoctoral Fellow

*Lyon, France*

THEORY GROUP, INSTITUT PHYSIQUE NUCLÉAIRE DE LYON (NOW IP2I LYON)

*Nov. 2016 - Sept. 2018*

SUBJECT: CONSTRUCTING A UNIVERSAL MICROSCOPIC MODEL FOR THE DESCRIPTION OF HEAVY NUCLEI

- Participated in the development of Skyrme functionals employing higher-order gradients: N2/3LO functionals.
- Performed first calculations for deformed nuclei using N2LO functionals
- Quantified the impact of the surface tension of Skyrme functionals on observables
- Developed algorithmic advances to speed up 3D EDF calculations by an order of magnitude

## Education

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### Université Libre de Bruxelles

*Brussels, Belgium*

PHD IN THEORETICAL NUCLEAR PHYSICS, SUPERVISOR: PROF. P.-H. HEENEN

*Oct. 2012 - Sept. 2016*

Thesis: [Symmetry conservation and breaking in nuclear mean-field models](#)

- Developed the MOCCa code: density-functional-solver in 3D coordinate space without symmetry assumptions
- Studied the numerical accuracy of coordinate-space representation
- Calculated charge radii of neutron-deficient Hg isotopes in support of the KULeuven group of P. Van Duppen

### Katholieke Universiteit Leuven

*Leuven, Belgium*

MASTER IN THEORETICAL PHYSICS, MAGNA CUM LAUDE

*Sept. 2010 - June 2012*

Thesis: [On the quantum-to-classical transition of primordial perturbations](#)

### Katholieke Universiteit Leuven

*Leuven, Belgium*

BACHELOR IN PHYSICS, CUM LAUDE

*Sept. 2007 - June 2010*

### College van het Eucharistisch Hart

*Essen, Belgium*

HIGH SCHOOL DIPLOMA, GREEK AND MATHEMATICS, MAGNA CUM LAUDE

*Sept. 2001 - June 2007*

# Research grants obtained

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## FNRS Postdoctoral Fellow

INSTITUT D'ASTRONOMIE ET D'ASTROPHYSIQUE, UNIVERSITÉ LIBRE DE BRUXELLES

Obtained competitive personal grant to join the Institut d'Astronomie et d'Astrophysique at ULB as postdoctoral fellow (fr: *chargé de recherches*) from the FNRS, one of two Belgian National Research Foundations.

Brussels, Belgium

Oct. 2020 - Oct. 2023

## Skills

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### LANGUAGES

**Native** Dutch  
**Fluent** French, English  
**Elementary** Spanish

### PROGRAMMING

**Languages** Fortran, python,  $\LaTeX$ , bash  
**Software** Keras, Unix, git, scipy, numpy, Lapack

## Teaching

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2014-15 **Nuclear and particle physics (PHYS-F305)**, Teaching assistant of Prof. P. Descouvemont. ULB  
2020-22 **Introductory Physics (PHYS-F103)**, Teaching assistant of Prof. A. Jorissen. ULB  
2020-21 **Introductory Physics (PHYS-F104)**, Teaching assistant of Profs. B. Clerbaux, M. Sferrazza and S. Detournay. ULB  
2021-22 **Physics 2 (PHYS-F205)**, Teaching assistant of Prof. I. Maris. ULB

## Publications & Communication

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- 16** peer-reviewed publications authored, among which are **2** conference proceedings and **8** first-author papers.
- 17** oral contributions to international conferences, outside Belgium.
- 3** posters presented to international conferences, outside Belgium.
- 9** oral contributions to workshops in Belgium.
- 6** invited seminars given, among which **5** outside Belgium.

## Service to the profession

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### MASTER STUDENTS SUPPORTED

2021-22 **Onur Yavas**, The impact of nuclear deformation on the neutron star crust ULB

### GRADUATE STUDENTS SUPPORTED

2016-18 **Pierre Becker**, Développement d'une interaction nucléaire effective de nouvelle génération IP2I  
2018-20 **Paul Fanto**, Statistical properties of nuclei: beyond the mean-field approximation Yale  
2018-20 **Sohan Vartak**, [PhD ongoing] Yale

### PEER REVIEW

**APS** **11** reviews for Physical Review A (**1**), Physical Review C (**7**) and Physical Review Letters (**3**).  
**Elsevier** **2** reviews for Computer Physics Communications(**1**) and Heliyon (**1**).  
**Springer** **5** reviews for European Journal of Physics A.

### PUBLICLY AVAILABLE COMPUTER CODES

**EV8** W.Ryssens, V. Hellemans, M. Bender and P.-H. Heenen, Comp. Phys. Comm. 187, 175 (2015). [\[GITHUB\]](#)  
**HF-SHELL** W. Ryssens and Y. Alhassid, Eur. Phys. J. A 57, 76 (2021). [\[GITHUB\]](#)

## References

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**Dr. T. Duguet** [CEA Saclay] [thomas.duguet@cea.fr](mailto:thomas.duguet@cea.fr)  
**Prof. Dr. Y. Alhassid** [Yale University] [yoram.alhassid@yale.edu](mailto:yoram.alhassid@yale.edu)  
**Dr. S. Goriely** [Université Libre de Bruxelles] [sgoriely@ulb.ac.be](mailto:sgoriely@ulb.ac.be)

## JOURNAL ARTICLES IN PREPARATION

1. The deformation energy surface and fission paths of even-even  $^{250-258}\text{No}$  isotopes, M. Bender and [W. Ryssens](#).
2. Skyrme-Hartree-Fock-Bogoliubov mass models on a 3D Mesh: time-odd terms and actinide fission barriers, [W. Ryssens](#), G. Scamps, S. Goriely and M. Bender.
3. Stabilising iterative approaches for nuclei with odd numbers of nucleons, [W. Ryssens](#).
4. Finite-temperature (Q)RPA for shell model Hamiltonians: the code HF-SHELL v2., [W. Ryssens](#) and Y. Alhassid.

## PEER-REVIEWED JOURNAL ARTICLES

1. Skyrme-Hartree-Fock-Bogoliubov mass models on a 3D Mesh: Effect of triaxial shape, G. Scamps, S. Goriely, E. Olsen, M. Bender and [W. Ryssens](#), *Eur. Phys. J. A* **57**, 333 (2021), [arXiv:2011.07904\[nucl-th\]](#).
2. Skyrme pseudopotentials with N2LO and N3LO terms, [W. Ryssens](#) and M. Bender, *Phys. Rev. C* **104**, 044308 (2021) [arXiv:2104.07697 \[nucl-th\]](#).
3. Strong enhancement of level densities in the crossover from spherical to deformed Neodymium isotopes, M. Guttormsen, Y. Alhassid, [W. Ryssens](#), K. O. Ay, M. Ozgur, E. Algin, A. C. Larsen, F. L. Bello Garrote, L. Crespo Campo, T. Dahl-Jacobsen, A. Gorgen, T. W. Hagen, V. W. Ingeberg; B. V. Kheswa, M. Klintefjord, J. E. Midtb, V. Modamio, T. Renstrm, E. Sahin, S. Siem, G. M. Tveten and F. Zeiser, *Phys. Lett. B* **816**, 136206 (2021), [arXiv:2012.01902\[nucl-ex\]](#).
4. Solution of the finite temperature HFB equations for shell model Hamiltonians: the code HF-SHELL, [W. Ryssens](#) and Y. Alhassid, *Eur. Phys. J. A* **57**, 76 (2021), [arXiv:2009.01205\[nucl-th\]](#).
5. Zero-pairing and zero-temperature limits of finite temperature Hartree-Fock- Bogoliubov equations, T. Duguet and [W. Ryssens](#), *Phys. Rev. C* **102**, 044328 (2020), [arXiv:2008.01859\[nucl-th\]](#).
6. Future of nuclear fission theory, M. Bender, R. Bernard, G. Bertsch, S. Chiba, J. Dobaczewski, N. Dubray, S. A. Giuliani, K. Hagino, D. Lacroix, Z. Li, P. Magierski, J. Maruhn, W. Nazarewicz, J. Pei, S. Pru, N. Pillet, J. Randrup, D. Regnier, P.-G. Reinhard, L. M. Robledo, [W. Ryssens](#), J. Sadukhan, G. Scamps, N. Schunck, C. Simenel, J. Skalski, I. Stetcu, P. Stevenson, S. Umar, M. Verriere, D. Vretenar, M. Warda and S. Åberg, *J. Phys. G* **47**, 113002 (2020), [arXiv:2005.10216\[nucl-th\]](#).
7. In-beam gamma-ray and electron spectroscopy of  $^{249,251}\text{Md}$ , R. Briselet, Ch. Theisen, B. Sulignano, M. Airiau, K. Auranen, D. M. Cox, F. Dechery, A. Drouart, Z. Favier, B. Gall, T. Goigoux, T. Grahn, P. T. Greenlees, K. Hauschild, A. Herzann, R.-D. Herzberg, U. Jakobsson, R. Julin, S. Juutinen, J. Konki, M. Leino, A. Lopez-Martens, A. Mistry, P. Nieminen, J. Pakarinen, P. Papadakis, P. Peura, E. Rey-Herme, P. Rahkila, J. Rubert, P. Ruotsalainen, M. Sandzelius, J. Saren, C. Scholey, J. Sorri, S. Stolze, J. Uusitalo, M. Vandebrouck, A. Ward, M. Zielińska, B. Bally, M. Bender and [W. Ryssens](#), *Phys. Rev. C* **101**, 014307 (2020), [arXiv:2001.10235 \[nucl-ex\]](#).
8. Search for octupole-deformed actinium isotopes using resonance ionization spectroscopy, E. Verstraelen, A. Teigelhofer, [W. Ryssens](#), F. Ames, A. Barzakh, M. Bender, R. Ferrer, S. Goriely, P.-H. Heenen, M. Huyse, P. Kunz, J. Lassen, V. Manea, S. Raeder and P. Van Duppen, *Phys. Rev. C* **100**, 044321 (2019).
9. Iterative optimization of nuclear energy density functionals in coordinate space. I. Heavy-Ball Dynamics and Density preconditioning, [W. Ryssens](#), M. Bender and P.-H. Heenen, *Eur. Phys. J. A* **55**, 93 (2019), [arXiv:1812.08262 \[nucl-th\]](#).
10. The impact of the surface energy coefficient on the deformation properties of atomic nuclei as predicted by Skyrme EDFs, [W. Ryssens](#), M. Bender, K. Bennaceur, P.-H. Heenen and J. Meyer, *Phys. Rev. C* **99**, 044315 (2019), [arXiv:1809.04406 \[nucl-th\]](#).
11. In-source laser resonance-ionization spectroscopy of neutron-deficient  $^{175-185}\text{Hg}$  isotopes, S. Sels, T. Day Goodacre, B. A. Marsh, A. Pastore, [W. Ryssens](#), Y. Tsunoda, N. Althubiti, B. Andel, A. N. Andreyev, D. Atanasov, A. E. Barzakh, M. Bender, J. Billowes, K. Blaum, T. E. Cocolios, J. G. Cubiss, J. Dobaczewski, G. J. Farooq-Smith, D. V. Fedorov, V. N. Fedosseev, K. T. Flanagan, L. P. Gaffney, L. Ghys, P.-H. Heenen, M. Huyse, S. Kreim, D. Lunney, K. M. Lynch, V. Manea, Y. Martinez Palenzuela, T. M. Medonca, P. L. Molkanov, T. Otsuka, J. P. Ramos, R. E. Rossel, S. Rothe, L. Schweikhard, M. D. Seliverstov, P. Spagnoletti, C. Van Beveren, P. Van Duppen, M. Veinhard, E. Verstraelen, A. Welker, K. Wendt, F. Wienholtz, R. N. Wolf and A. Zadornaya, *Phys. Rev. C* **99**, 044306 (2019), [arXiv:1902.11211\[nucl-ex\]](#).

12. De-excitation of the strongly coupled band in  $^{177}\text{Au}$  and implications for core intruder configurations in the light Hg isotopes, M. Venhart, F. A. Ali, W. Ryssens, J. L. Wood, D. T. Joss, A. N. Andreyev, K. Auranen, B. Bally, M. Balogh, M. Bender, R. J. Carroll, J. L. Easton, P. T. Greenlees, T. Grahn, P.-H. Heenen, A. Herzán, U. Jakobsson, R. Julin, S. Juutinen, D. Kíř, J. Konki, E. Lawrie, M. Leino, V. Matoušek, C. G. McPeake, D. O'Donnell, R. D. Page, J. Pakarinen, J. Partanen, P. Peura, P. Rahkila, P. Ruotsalainen, M. Sandzelius, J. Sarén, B. Sayđi, M. Sedlák, C. Scholey, J. Sorri, S. Stolze, A. Thorntwaite, J. Uusitalo and M. Veselský, *Phys. Rev. C* **95**, 061302 (2017).
13. Numerical accuracy of mean-field calculations in coordinate space, W. Ryssens, P.-H. Heenen and M. Bender, *Phys. Rev. C* **92**, 064318 (2015), [arXiv:1509.00252 \[nucl-th\]](https://arxiv.org/abs/1509.00252).
14. Solution of the Skyrme-HF+BCS equation on a 3D mesh, II: A new version of the EV8 code, W. Ryssens, V. Hellemans, M. Bender and P.-H. Heenen, *Comp. Phys. Comm.* **187**, 175 (2015), [arXiv:1405.1897 \[nucl-th\]](https://arxiv.org/abs/1405.1897).

## PEER-REVIEWED CONFERENCE PROCEEDINGS

1. Towards symmetry-unrestricted Skyrme-HFB in coordinate-space representation: the example of rotational bands of the octupole deformed nucleus  $^{222}\text{Th}$ . W. Ryssens, M. Bender and P.-H. Heenen, *Acta Physica Polonica B*, Vol. 49 (2018), [arxiv:1712.03734 \[nucl-th\]](https://arxiv.org/abs/1712.03734).
2. Symmetry unrestricted Skyrme mean-field study of heavy nuclei, W. Ryssens, P.-H. Heenen and M. Bender, in proceedings of 54th International Winter Meeting on Nuclear Physics PoS(**BORMIO2016**) 033, [arXiv:11611.01300 \[nucl-th\]](https://arxiv.org/abs/11611.01300)