

Search

- [Log in](#)

Search SpringerLink

 Search

- Regular Article – Experimental Physics
- [Published: 06 April 2020](#)

Spin assignments for ^{23}Mg levels and the astrophysical $^{22}\text{Na}(p, \gamma)^{23}\text{Mg}$ reaction

- [M. S. Kwag¹](#),
- [K. Y. Chae¹](#) ,
- [S. Ahn²](#),
- [D. W. Bardayan³](#),
- [K. A. Chipps⁴](#),
- [J. A. Cizewski⁵](#),
- [M. E. Howard⁵](#),
- [R. L. Kozub⁶](#),
- [K. Kwak⁷](#),
- [B. Manning⁵](#),
- [M. Matos⁸](#),
- [P. D. O'Malley⁵](#),
- [S. D. Pain⁹](#),
- [W. A. Peters¹⁰](#),
- [S. T. Pittman⁹](#),
- [A. Ratkiewicz⁵](#),
- [\[...\]](#)
- [M. S. Smith⁹](#) &
- [S. Strauss⁵](#)
- [-Show fewer authors](#)

[The European Physical Journal A](#) **volume 56**, Article number: 108 (2020) [Cite this article](#)

- 114 Accesses
- [Metrics details](#)

Abstract

The $^{22}\text{Na}(p, \gamma)^{23}\text{Mg}$ reaction is responsible for destruction of the long-lived radionuclide ^{22}Na produced during nova explosions. Since the reaction proceeds through resonances from levels in ^{23}Mg above the proton threshold at 7.581 MeV, the properties of these levels such as excitation energies, spins, and parities are crucial

ingredients to determine the $^{22}\text{Na}(p,\gamma)^{23}\text{Mg}$ reaction rate. Despite recent studies of these levels, their spins are not well constrained in many cases. We have measured the $^{24}\text{Mg}(p,d)^{23}\text{Mg}$ transfer reaction to determine spectroscopic properties of these levels at the Holifield Radioactive Ion Beam Facility at Oak Ridge National Laboratory. The spin of the $E_x = 7.788$ MeV level in ^{23}Mg is constrained to be $J^\pi = (3/2^+, 5/2^+)$ through the present work. The astrophysical $^{22}\text{Na}(p,\gamma)^{23}\text{Mg}$ reaction rate at nova temperatures is updated accordingly. Nova nucleosynthesis model calculations using the newly updated $^{22}\text{Na}(p,\gamma)^{23}\text{Mg}$ reaction rate shows that the final weighted abundance of the radionuclide ^{22}Na is increased by 42% compared to that obtained by using the previous $^{22}\text{Na}(p,\gamma)^{23}\text{Mg}$ reaction rate of Sallaska et al. for a $1.35 M_\odot$ ONeMg white dwarf.

This is a preview of subscription content, [log in](#) to check access.

Access options		
Buy article PDF US\$ 39.95 Price includes VAT for USA Instant access to the full article PDF.	Buy journal subscription US\$ 199 This is the net price. Taxes to be calculated in checkout. Immediate online access to all issues from 2019. Subscription will auto renew annually.	Rent this article via DeepDyve.
Learn more about Institutional subscriptions		

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6**Fig. 7****Fig. 8**

Data Availability Statement

This manuscript has no associated data or the data will not be deposited. [Authors' comment: All data generated during this study are contained in the published article.]

References

1. 1.

M. Hernanz, J. José, New Astron. Rev. **48**, 35 (2004)

[ADS](#) [Article](#) [Google Scholar](#)

2. 2.

A.L. Sallaska et al., Phys. Rev. C **83**, 034611 (2011)

[ADS](#) [Article](#) [Google Scholar](#)

3. 3.

S.E. Boggs, New Astron. Rev. **50**, 604 (2006)

[ADS](#) [Article](#) [Google Scholar](#)

4. 4.

A. De Angelis et al., J. High Energy Astrophys. **19**, 1 (2018)

[ADS](#) [Article](#) [Google Scholar](#)

5. 5.

D.D. Clayton, F. Hoyle, Astrophys. J. **187**, L101 (1974)

[ADS](#) [Article](#) [Google Scholar](#)

6. 6.

J. José, A. Coc, M. Hernanz, Astrophys. J. **520**, 347 (1999)

[ADS](#) [Article](#) [Google Scholar](#)

7. 7.

C. Iliadis, A. Champagne, J. José, S. Starrfield, P. Tupper, Astrophys. J. Suppl. Ser. **142**, 105 (2002)

[ADS](#) [Article](#) [Google Scholar](#)

8. 8.

W.R. Hix, M.S. Smith, S. Starrfield, A. Mezzacappa, D.L. Smith, Nucl. Phys. A **718**, 620 (2003)

[ADS](#) [Article](#) [Google Scholar](#)

9. 9.

M. Wang, G. Audi, F.G. Kondev, W.J. Huang, S. Naimi, X. Xu, Chin. Phys. C **41**, 030003 (2017)

[ADS](#) [Article](#) [Google Scholar](#)

10. 10.

S. Seuthe, C. Rolfs, U. Schröder, W.H. Schulte, E. Somorjai, H.P. Trautvetter, F.B. Waanders, Nucl. Phys. A **514**, 471 (1990)

[ADS](#) [Article](#) [Google Scholar](#)

11. 11.

F. Stegmüller, C. Rolfs, S. Schmidt, W.H. Schulte, H.P. Trautvetter, R.W. Kavanagh, Nucl. Phys. A **601**, 168 (1996)

[ADS](#) [Article](#) [Google Scholar](#)

12. 12.

A.F. Iyudin et al., Astron. Astrophys. **300**, 422 (1995)

[ADS](#) [Google Scholar](#)

13. 13.

L.C. Haun, N.R. Roberson, Nucl. Phys. A **140**, 333 (1970)

[ADS](#) [Article](#) [Google Scholar](#)

14. 14.

H. Nann, A. Saha, B.H. Wildenthal, Phys. Rev. C **23**, 606 (1981)

[ADS](#) [Article](#) [Google Scholar](#)

15. 15.

S. Schmidt, C. Rolfs, W.H. Schulte, H.P. Trautvetter, R.W. Kavanagh, C. Hategan, S. Faber, B.D. Valnion, G. Graw, Nucl. Phys. A **591**, 227 (1995)

[ADS](#) [Article](#) [Google Scholar](#)

16. 16.

R.L. Kozub, Phys. Rev. **172**, 1078 (1968)

[ADS](#) [Article](#) [Google Scholar](#)

17. 17.

J. Källne, B. Fagerström, Phys. Scr. **11**, 79 (1975)

[ADS](#) [Article](#) [Google Scholar](#)

18. 18.

D.W. Miller et al., Phys. Rev. C **20**, 2008 (1979)

[ADS](#) [Article](#) [Google Scholar](#)

M. Wiescher, K. Langanke, Z. Phys. A **325**, 309 (1986)

[ADS](#) [Google Scholar](#)

29. 29.

V. Tripathi, S.L. Tabor, A. Volya, S.N. Liddick, P.C. Bender, N. Larson, C. Prokop, S. Suchyta, P.L. Tai, J.M. VonMoss, Phys. Rev. Lett. **111**, 262501 (2013)

[ADS](#) [Article](#) [Google Scholar](#)

30. 30.

R.J. Tighe, J.C. Batchelder, D.M. Moltz, T.J. Ognibene, M.W. Rowe, J. Cerny, B.A. Brown, Phys. Rev. C **52**, R2298 (1995)

[ADS](#) [Article](#) [Google Scholar](#)

31. 31.

S.J. Jin et al., Phys. Rev. C **88**, 035801 (2013)

[ADS](#) [Article](#) [Google Scholar](#)

32. 32.

R.H. Cyburt et al., Astrophys. J. Suppl. Ser. **189**, 240 (2010)

[ADS](#) [Article](#) [Google Scholar](#)

33. 33.

C. Iliadis, R. Longland, A.E. Champagne, A. Coc, R. Fitzgerald, Nucl. Phys. A **841**, 31 (2010)

[ADS](#) [Article](#) [Google Scholar](#)

34. 34.

<http://nucastrodata.org>

35. 35.

S. Starrfield, C. Iliadis, W.R. Hix, F.X. Timmes, W.M. Sparks, Astrophys. J. **692**, 1532 (2009)

[ADS](#) [Article](#) [Google Scholar](#)

36. 36.

S. Starrfield, J.W. Truran, M.C. Wiescher, W.M. Sparks, Mon. Not. R. Astron. Soc. **296**, 502 (1998)

[ADS](#) [Article](#) [Google Scholar](#)

37. 37.

J. José, M. Hernanz, Astrophys. J. **494**, 680 (1998)

[ADS](#) [Article](#) [Google Scholar](#)

[Download references](#) 

10. Oak Ridge Associated Universities, Oak Ridge, TN, 37831, USA

W. A. Peters

Authors

1. M. S. Kwag

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

2. K. Y. Chae

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

3. S. Ahn

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

4. D. W. Bardayan

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

5. K. A. Chipps

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

6. J. A. Cizewski

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

7. M. E. Howard

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

8. R. L. Kozub

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

9. K. Kwak

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

10. B. Manning

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

11. M. Matos

You can also search for this author in [PubMed](#) [Google Scholar](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

Correspondence to [K. Y. Chae](#).

Communicated by Philip J. Woods

Reprints and Permissions

11/20



Check for
updates

Cite this article

Kwag, M.S., Chae, K.Y., Ahn, S. *et al.* Spin assignments for ^{23}Mg levels and the astrophysical $^{22}\text{Na}(p,\gamma)^{23}\text{Mg}$ reaction. *Eur. Phys. J. A* **56**, 108 (2020). <https://doi.org/10.1140/epja/s10050-020-00106-y>

[Download citation](#)

- Received: 20 October 2019
- Accepted: 18 February 2020
- Published: 06 April 2020
- DOI: <https://doi.org/10.1140/epja/s10050-020-00106-y>

Access options

Buy article PDF

US\$ 39.95

Price **includes VAT** for USA

Instant access to the full article PDF.

Buy journal subscription

US\$ 199

This is the **net price**. Taxes to be calculated in checkout.

Immediate online access to all issues from 2019.
Subscription will auto renew annually.

[Rent this article via DeepDyve.](#)

[Learn more about Institutional subscriptions](#)

- [Sections](#)
- [Figures](#)
- [References](#)

- [Abstract](#)
- [Data Availability Statement](#)
- [References](#)
- [Acknowledgements](#)
- [Author information](#)
- [Additional information](#)
- [Rights and permissions](#)
- [About this article](#)

- **Fig. 1**

- **Fig. 2**

- **Fig. 3**

- **Fig. 4**

- **Fig. 5**

- **Fig. 6**

- **Fig. 7**

- **Fig. 8**

1. M. Hernanz, J. José, New Astron. Rev. **48**, 35 (2004)

[ADS Article](#) [Google Scholar](#)

2. A.L. Sallaska et al., Phys. Rev. C **83**, 034611 (2011)

[ADS Article](#) [Google Scholar](#)

3. S.E. Boggs, New Astron. Rev. **50**, 604 (2006)

[ADS Article](#) [Google Scholar](#)

4. A. De Angelis et al., J. High Energy Astrophys. **19**, 1 (2018)

[ADS Article](#) [Google Scholar](#)

5. D.D. Clayton, F. Hoyle, *Astrophys. J.* **187**, L101 (1974)

[ADS Article](#) [Google Scholar](#)

6. J. José, A. Coc, M. Hernanz, *Astrophys. J.* **520**, 347 (1999)

[ADS Article](#) [Google Scholar](#)

7. C. Iliadis, A. Champagne, J. José, S. Starrfield, P. Tupper, *Astrophys. J. Suppl. Ser.* **142**, 105 (2002)

[ADS Article](#) [Google Scholar](#)

8. W.R. Hix, M.S. Smith, S. Starrfield, A. Mezzacappa, D.L. Smith, *Nucl. Phys. A* **718**, 620 (2003)

[ADS Article](#) [Google Scholar](#)

9. M. Wang, G. Audi, F.G. Kondev, W.J. Huang, S. Naimi, X. Xu, *Chin. Phys. C* **41**, 030003 (2017)

[ADS Article](#) [Google Scholar](#)

10. S. Seuthe, C. Rolfs, U. Schröder, W.H. Schulte, E. Somorjai, H.P. Trautvetter, F.B. Waanders, *Nucl. Phys. A* **514**, 471 (1990)

[ADS Article](#) [Google Scholar](#)

11. F. Stegmüller, C. Rolfs, S. Schmidt, W.H. Schulte, H.P. Trautvetter, R.W. Kavanagh, *Nucl. Phys. A* **601**, 168 (1996)

[ADS Article](#) [Google Scholar](#)

12. A.F. Iyudin et al., *Astron. Astrophys.* **300**, 422 (1995)

[ADS](#) [Google Scholar](#)

13. L.C. Haun, N.R. Roberson, *Nucl. Phys. A* **140**, 333 (1970)

[ADS Article](#) [Google Scholar](#)

14. H. Nann, A. Saha, B.H. Wildenthal, *Phys. Rev. C* **23**, 606 (1981)

[ADS Article](#) [Google Scholar](#)

15. S. Schmidt, C. Rolfs, W.H. Schulte, H.P. Trautvetter, R.W. Kavanagh, C. Hategan, S. Faber, B.D. Valnion, G. Graw, *Nucl. Phys. A* **591**, 227 (1995)

[ADS Article](#) [Google Scholar](#)

16. R.L. Kozub, *Phys. Rev.* **172**, 1078 (1968)

[ADS Article](#) [Google Scholar](#)

17. J. Källne, B. Fagerström, *Phys. Scr.* **11**, 79 (1975)

[ADS Article](#) [Google Scholar](#)

18. D.W. Miller et al., *Phys. Rev. C* **20**, 2008 (1979)

[ADS](#) [Article](#) [Google Scholar](#)

19. S. Kubono et al., Z. Phys. A **348**, 59 (1994)

[ADS](#) [Article](#) [Google Scholar](#)

20. D.W. Bardayan et al., Phys. Rev. C **63**, 065802 (2001)

[ADS](#) [Article](#) [Google Scholar](#)

21. R.B. Firestone, Nucl. Data Sheets **108**, 1 (2007)

[ADS](#) [Article](#) [Google Scholar](#)

22. D.G. Jenkins et al., Phys. Rev. C **87**, 064301 (2013)

[ADS](#) [Article](#) [Google Scholar](#)

23. P.D. Kunz. <http://spot.colorado.edu/~kunz/>(unpublished)

24. I.Y. Lee, Nucl. Phys. A **520**, 641c (1990)

[ADS](#) [Article](#) [Google Scholar](#)

25. A. Krämer-Flecken, T. Morek, R.M. Lieder, W. Gast, G. Hebbinghaus, H.M. Jäger, W. Urban, Nucl. Instrum. Methods A **275**, 333 (1989)

[ADS](#) [Article](#) [Google Scholar](#)

26. A. Saastamoinen et al., Phys. Rev. C **83**, 045808 (2011)

[ADS](#) [Article](#) [Google Scholar](#)

27. O.S. Kirsebom et al., Phys. Rev. C **93**, 025802 (2016)

[ADS](#) [Article](#) [Google Scholar](#)

28. M. Wiescher, K. Langanke, Z. Phys. A **325**, 309 (1986)

[ADS](#) [Google Scholar](#)

29. V. Tripathi, S.L. Tabor, A. Volya, S.N. Liddick, P.C. Bender, N. Larson, C. Prokop, S. Suchyta, P.L. Tai, J.M. VonMoss, Phys. Rev. Lett. **111**, 262501 (2013)

[ADS](#) [Article](#) [Google Scholar](#)

30. R.J. Tighe, J.C. Batchelder, D.M. Moltz, T.J. Ognibene, M.W. Rowe, J. Cerny, B.A. Brown, Phys. Rev. C **52**, R2298 (1995)

[ADS](#) [Article](#) [Google Scholar](#)

31. S.J. Jin et al., Phys. Rev. C **88**, 035801 (2013)

[ADS](#) [Article](#) [Google Scholar](#)

32. R.H. Cyburt et al., Astrophys. J. Suppl. Ser. **189**, 240 (2010)

[ADS Article](#) [Google Scholar](#)

33. C. Iliadis, R. Longland, A.E. Champagne, A. Coc, R. Fitzgerald, Nucl. Phys. A **841**, 31 (2010)

[ADS Article](#) [Google Scholar](#)

34. <http://nucastrodata.org>

35. S. Starrfield, C. Iliadis, W.R. Hix, F.X. Timmes, W.M. Sparks, Astrophys. J. **692**, 1532 (2009)

[ADS Article](#) [Google Scholar](#)

36. S. Starrfield, J.W. Truran, M.C. Wiescher, W.M. Sparks, Mon. Not. R. Astron. Soc. **296**, 502 (1998)

[ADS Article](#) [Google Scholar](#)

37. J. José, M. Hernanz, Astrophys. J. **494**, 680 (1998)

[ADS Article](#) [Google Scholar](#)

Over 10 million scientific documents at your fingertips

Switch Edition

- [Academic Edition](#)
- [Corporate Edition](#)
- [Home](#)
- [Impressum](#)
- [Legal information](#)
- [Privacy statement](#)
- [California Privacy Statement](#)
- [How we use cookies](#)
- [Manage cookies/Do not sell my data](#)
- [Accessibility](#)
- [Contact us](#)

Not logged in - 98.32.235.17

Not affiliated

[Springer Nature](#) **SPRINGER NATURE**

© 2020 Springer Nature Switzerland AG. Part of [Springer Nature](#).

- Department of Physics, Sungkyunkwan University, Suwon, 16149, South Korea

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

K. Y. Chae

- Department of Physics, Sungkyunkwan University, Suwon, 16149, South Korea
- [Contact K. Y. Chae](#)

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

S. Ahn

- Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee, 37996, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

D. W. Bardayan

- Department of Physics, University of Notre Dame, Notre Dame, IN, 46556, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

K. A. Chipps

- Department of Physics, Colorado School of Mines, Golden, CO, 80401, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

J. A. Cizewski

- Department of Physics and Astronomy, Rutgers University, New Brunswick, NJ, 08903, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

M. E. Howard

- Department of Physics and Astronomy, Rutgers University, New Brunswick, NJ, 08903, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

R. L. Kozub

- Department of Physics, Tennessee Technological University, Cookeville, TN, 38505, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

K. Kwak

- Department of Physics, School of Natural Science, Ulsan National Institute of Science and Technology (UNIST), Ulsan, 44919, South Korea

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

B. Manning

- Department of Physics and Astronomy, Rutgers University, New Brunswick, NJ, 08903, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

M. Matos

- Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA, 70803, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

P. D. O'Malley

- Department of Physics and Astronomy, Rutgers University, New Brunswick, NJ, 08903, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

S. D. Pain

- Physics Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

W. A. Peters

- Oak Ridge Associated Universities, Oak Ridge, TN, 37831, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

S. T. Pittman

- Physics Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

A. Ratkiewicz

- Department of Physics and Astronomy, Rutgers University, New Brunswick, NJ, 08903, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

M. S. Smith

- Physics Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)

S. Strauss

- Department of Physics and Astronomy, Rutgers University, New Brunswick, NJ, 08903, USA

[View author publications](#)

You can also search for this author in [PubMed](#) [Google Scholar](#)

[Close](#)