



HAL
open science

Gaia Data Release 2

A. Helmi, F. van Leeuwen, P. Mcmillan, D. Massari, T. Antoja, A. Robin, L. Lindegren, U. Bastian, F. Arenou, C. Babusiaux, et al.

► **To cite this version:**

A. Helmi, F. van Leeuwen, P. Mcmillan, D. Massari, T. Antoja, et al.. Gaia Data Release 2. Astronomy and Astrophysics - A&A, 2020, 642, pp.C1. 10.1051/0004-6361/202039217 . hal-03239695

HAL Id: hal-03239695

<https://hal.science/hal-03239695>

Submitted on 28 Aug 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution| 4.0 International License

Gaia Data Release 2

The kinematics of globular clusters and dwarf galaxies around the Milky Way

(Corrigendum)

Gaia Collaboration, A. Helmi^{1,*}, F. van Leeuwen², P. J. McMillan³, D. Massari¹, T. Antoja^{4,5}, A. C. Robin⁶, L. Lindegren³, U. Bastian⁷, F. Arenou⁸, C. Babusiaux^{8,9}, M. Biermann⁷, M. A. Breddels¹, D. Hobbs³, C. Jordi⁵, E. Pancino^{10,11}, C. Reylé⁶, J. Veljanoski¹, A. G. A. Brown¹², A. Vallenari¹³, T. Prusti⁴, J. H. J. de Bruijne⁴, C. A. L. Bailer-Jones¹⁴, D. W. Evans², L. Eyer¹⁵, F. Jansen¹⁶, S. A. Klioner¹⁷, U. Lammers¹⁸, X. Luri⁵, F. Mignard¹⁹, C. Panem²⁰, D. Pourbaix^{21,22}, S. Randich¹⁰, P. Sartoretti⁸, H. I. Siddiqui²³, C. Soubiran²⁴, N. A. Walton², M. Cropper²⁵, R. Drimmel²⁶, D. Katz⁸, M. G. Lattanzi²⁶, J. Bakker¹⁸, C. Cacciari²⁷, J. Castañeda⁵, L. Chaoul²⁰, N. Cheek²⁸, F. De Angeli², C. Fabricius⁵, R. Guerra¹⁸, B. Holl¹⁵, E. Masana⁵, R. Messineo²⁹, N. Mowlavi¹⁵, K. Nienartowicz³⁰, P. Panuzzo⁸, J. Portell⁵, M. Riello², G. M. Seabroke²⁵, P. Tanga¹⁹, F. Thévenin¹⁹, G. Gracia-Abril^{31,7}, G. Comoretto²³, M. Garcia-Reinaldos¹⁸, D. Teyssier²³, M. Altmann^{7,32}, R. Andrae¹⁴, M. Audard¹⁵, I. Bellas-Velidis³³, K. Benson²⁵, J. Berthier³⁴, R. Blomme³⁵, P. Burgess², G. Busso², B. Carry^{19,34}, A. Cellino²⁶, G. Clementini²⁷, M. Clotet⁵, O. Creevey^{19,36}, M. Davidson³⁷, J. De Ridder³⁸, L. Delchambre³⁹, A. Dell’Oro¹⁰, C. Ducourant²⁴, J. Fernández-Hernández⁴⁰, M. Fouesneau¹⁴, Y. Frémat³⁵, L. Galluccio¹⁹, M. García-Torres⁴¹, J. González-Núñez^{28,42}, J. J. González-Vidal⁵, E. Gosset^{39,22}, L. P. Guy^{30,43}, J.-L. Halbwachs⁴⁴, N. C. Hambly³⁷, D. L. Harrison^{2,45}, J. Hernández¹⁸, D. Hestroffer³⁴, S. T. Hodgkin², A. Hutton⁴⁶, G. Jasiewicz⁴⁷, A. Jean-Antoine-Piccolo²⁰, S. Jordan⁷, A. J. Korn⁴⁸, A. Krone-Martins⁴⁹, A. C. Lanzafame^{50,51}, T. Lebzelter⁵², W. Löffler⁷, M. Manteiga^{53,54}, P. M. Marrese^{55,11}, J. M. Martín-Fleitas⁴⁶, A. Moitinho⁴⁹, A. Mora⁴⁶, K. Muinonen^{56,57}, J. Osinde⁵⁸, T. Pauwels³⁵, J.-M. Petit⁶, A. Recio-Blanco¹⁹, P. J. Richards⁵⁹, L. Rimoldini³⁰, L. M. Sarro⁶⁰, C. Siopis²¹, M. Smith²⁵, A. Sozzetti²⁶, M. Süveges¹⁴, J. Torra⁵, W. van Reeve⁴⁶, U. Abbas²⁶, A. Abreu Aramburu⁶¹, S. Accart⁶², C. Aerts^{38,63}, G. Altavilla^{55,11,27}, M. A. Álvarez⁵³, R. Alvarez¹⁸, J. Alves⁵², R. I. Anderson^{64,15}, A. H. Andrei^{65,66,32}, E. Anglada Varela⁴⁰, E. Antiche⁵, B. Arcay⁵³, T. L. Astraatmadja^{14,67}, N. Bach⁴⁶, S. G. Baker²⁵, L. Balaguer-Núñez⁵, P. Balm²³, C. Barache³², C. Barata⁴⁹, D. Barbato^{68,26}, F. Barblan¹⁵, P. S. Barklem⁴⁸, D. Barrado⁶⁹, M. Barros⁴⁹, M. A. Barstow⁷⁰, S. Bartholomé Muñoz⁵, J.-L. Basilana⁶², U. Becciani⁵¹, M. Bellazzini²⁷, A. Berihuete⁷¹, S. Bertone^{26,32,72}, L. Bianchi⁷³, O. Bienaymé⁴⁴, S. Blanco-Cuaresma^{15,24,74}, T. Boch⁴⁴, C. Boeche¹³, A. Bombrun⁷⁵, R. Borrachero⁵, D. Bossini¹³, S. Bouquillon³², G. Bourda²⁴, A. Bragaglia²⁷, L. Bramante²⁹, A. Bressan⁷⁶, N. Brouillet²⁴, T. Brüsmeister⁷, E. Brugaletta⁵¹, B. Bucciarelli²⁶, A. Burlacu²⁰, D. Busonero²⁶, A. G. Butkevich¹⁷, R. Buzzzi²⁶, E. Caffau⁸, R. Cancelliere⁷⁷, G. Cannizzaro^{78,63}, T. Cantat-Gaudin^{13,5}, R. Carballo⁷⁹, T. Carlucci³², J. M. Carrasco⁵, L. Casamiquela⁵, M. Castellani⁵⁵, A. Castro-Ginard⁵, P. Charlot²⁴, L. Chemin⁸⁰, A. Chiavassa¹⁹, G. Cocozza²⁷, G. Costigan¹², S. Cowell², F. Crifo⁸, M. Crosta²⁶, C. Crowley⁷⁵, J. Cuypers^{†35}, C. Dafonte⁵³, Y. Damerdjji^{39,81}, A. Dapergolas³³, P. David³⁴, M. David⁸², P. de Laverny¹⁹, F. De Luise⁸³, R. De March²⁹, D. de Martino⁸⁴, R. de Souza⁸⁵, A. de Torres⁷⁵, J. Debosscher³⁸, E. del Pozo⁴⁶, M. Delbo¹⁹, A. Delgado², H. E. Delgado⁶⁰, P. Di Matteo⁸, S. Diakite⁶, C. Diener², E. Distefano⁵¹, C. Dolding²⁵, P. Drazinos⁸⁶, J. Durán⁵⁸, B. Edvardsson⁴⁸, H. Enke⁸⁷, K. Eriksson⁴⁸, P. Esquej⁸⁸, G. Eynard Bontemps²⁰, C. Fabre⁸⁹, M. Fabrizio^{55,11}, S. Faigler⁹⁰, A. J. Falcão⁹¹, M. Farràs Casas⁵, L. Federici²⁷, G. Fedorets⁵⁶, P. Fernique⁴⁴, F. Figueras⁵, F. Filippi²⁹, K. Findeisen⁸, A. Fonti²⁹, E. Fraile⁸⁸, M. Fraser^{2,92}, B. Frézouls²⁰, M. Gai²⁶, S. Galleti²⁷, D. Garabato⁵³, F. García-Sedano⁶⁰, A. Garofalo^{93,27}, N. Garralda⁵, A. Gavel⁴⁸, P. Gavras^{8,33,86}, J. Gerssen⁸⁷, R. Geyer¹⁷, P. Giacobbe²⁶, G. Gilmore², S. Girona⁹⁴, G. Giuffrida^{11,55}, F. Glass¹⁵, M. Gomes⁴⁹, M. Granvik^{56,95}, A. Gueguen^{8,96}, A. Guerrier⁶², J. Guiraud²⁰, R. Gutiérrez-Sánchez²³, R. Haigron⁸, D. Hatzidimitriou^{86,33}, M. Hauser^{7,14}, M. Haywood⁸, U. Heiter⁴⁸, J. Heu⁸, T. Hilger¹⁷, W. Hofmann⁷, G. Holland², H. E. Huckle²⁵, A. Hypki^{12,97}, V. Icardi²⁹, K. Janßen⁸⁷, G. Jevardat de Fombelle³⁰, P. G. Jonker^{78,63}, Á. L. Juhász^{98,99}, F. Julbe⁵, A. Karamelas^{86,100}, A. Kewley², J. Klar⁸⁷, A. Kochoska^{101,102}, R. Kohley¹⁸, K. Kolenberg^{103,38,74}, M. Kontizas⁸⁶, E. Kontizas³³, S. E. Koposov^{2,104},

* Corresponding author: A. Helmi, e-mail: ahelmi@astro.rug.nl

G. Kordopatis¹⁹, Z. Kostrzewa-Rutkowska^{78,63}, P. Koubsky¹⁰⁵, S. Lambert³², A. F. Lanza⁵¹, Y. Lasne⁶², J.-B. Lavigne⁶², Y. Le Fustec¹⁰⁶, C. Le Poncin-Lafitte³², Y. Lebreton^{8,107}, S. Leccia⁸⁴, N. Leclerc⁸, I. Lecoœur-Taïbi³⁰, H. Lenhardt⁷, F. Leroux⁶², S. Liao^{26,108,109}, E. Licata⁷³, H. E. P. Lindstrøm^{110,111}, T. A. Lister¹¹², E. Livanou⁸⁶, A. Lobel³⁵, M. López⁶⁹, S. Managau⁶², R. G. Mann³⁷, G. Mantelet⁷, O. Marchal⁸, J. M. Marchant¹¹³, M. Marconi⁸⁴, S. Marinoni^{55,11}, G. Marschalkó^{98,114}, D. J. Marshall¹¹⁵, M. Martino²⁹, G. Marton⁹⁸, N. Mary⁶², G. Matijević⁸⁷, T. Mazeh⁹⁰, S. Messina⁵¹, D. Michalik³, N. R. Millar², D. Molina⁵, R. Molinaro⁸⁴, L. Molnár⁹⁸, P. Montegriffo²⁷, R. Mor⁵, R. Morbidelli²⁶, T. Morel³⁹, D. Morris³⁷, A. F. Mulone²⁹, T. Muraveva²⁷, I. Musella⁸⁴, G. Nelemans^{63,38}, L. Nicastro²⁷, L. Noval⁶², W. O'Mullane^{18,43}, C. Ordénovic¹⁹, D. Ordóñez-Blanco³⁰, P. Osborne², C. Pagani⁷⁰, I. Pagano⁵¹, F. Pailler²⁰, H. Palacin⁶², L. Palaversa^{2,15}, A. Panahi⁹⁰, M. Pawlak^{116,117}, A. M. Piersimoni⁸³, F.-X. Pineau⁴⁴, E. Plachy⁹⁸, G. Plum⁸, E. Poggio^{68,26}, E. Poujoulet¹¹⁸, A. Prša¹⁰², L. Pulone⁵⁵, E. Racero²⁸, S. Ragaini²⁷, N. Rambaux³⁴, M. Ramos-Lerate¹¹⁹, S. Regibo³⁸, F. Riclet²⁰, V. Ripepi⁸⁴, A. Riva²⁶, A. Rivard⁶², G. Rixon², T. Roegiers¹²⁰, M. Roelens¹⁵, M. Romero-Gómez⁵, N. Rowell³⁷, F. Royer⁸, L. Ruiz-Dern⁸, G. Sadowski²¹, T. Sagristà Sellés⁷, J. Sahlmann^{18,121}, J. Salgado¹²², E. Salguero⁴⁰, N. Sanna¹⁰, T. Santana-Ros⁹⁷, M. Sarasso²⁶, H. Savietto¹²³, M. Schultheis¹⁹, E. Sciacca⁵¹, M. Segol¹²⁴, J. C. Segovia²⁸, D. Ségransan¹⁵, I.-C. Shih⁸, L. Siltala^{56,125}, A. F. Silva⁴⁹, R. L. Smart²⁶, K. W. Smith¹⁴, E. Solano^{69,126}, F. Solitro²⁹, R. Sordo¹³, S. Soria Nieto⁵, J. Souchay³², A. Spagna²⁶, F. Spoto^{19,34}, U. Stampa⁷, I. A. Steele¹¹³, H. Steidelmüller¹⁷, C. A. Stephenson²³, H. Stoev¹²⁷, F. F. Suess², J. Surdej³⁹, L. Szabados⁹⁸, E. Szegedi-Elek⁹⁸, D. Tapiador^{128,129}, F. Taris³², G. Tauran⁶², M. B. Taylor¹³⁰, R. Teixeira⁸⁵, D. Terrett⁵⁹, P. Teyssandier³², W. Thuillot³⁴, A. Titarenko¹⁹, F. Torra Clotet¹³¹, C. Turon⁸, A. Ulla¹³², E. Utrilla⁴⁶, S. Uzzi²⁹, M. Vaillant⁶², G. Valentini⁸³, V. Valette²⁰, A. van Elteren¹², E. Van Hemelryck³⁵, M. van Leeuwen², M. Vaschetto²⁹, A. Vecchiato²⁶, Y. Viala⁸, D. Vicente⁹⁴, S. Vogt¹²⁰, C. von Essen¹³³, H. Voss⁵, V. Votruba¹⁰⁵, S. Voutsinas³⁷, G. Walmsley²⁰, M. Weiler⁵, O. Wertz¹³⁴, T. Wevers^{2,63}, Ł. Wyrzykowski^{2,116}, A. Yoldas², M. Žerjal^{101,135}, H. Ziaepour⁶, J. Zorec¹³⁶, S. Zschocke¹⁷, S. Zucker¹³⁷, C. Zurbach⁴⁷, and T. Zwitter¹⁰¹

(Affiliations can be found after the references)

A&A, 616, A12 (2018), <https://doi.org/10.1051/0004-6361/201832698>

Key words. Galaxy: kinematics and dynamics – astrometry – Magellanic Clouds – galaxies: dwarf – Local Group – errata, addenda

This is a corrigendum to [Gaia Collaboration \(2018\)](#). It corrects errors in Appendix B, which describes the modelling of the Large and Small Magellanic Clouds (LMC and SMC). One of these errors also affects Fig. 18 of the paper, which shows the rotation curve and median radial motion in the LMC. No other results in the paper are affected.

There should be no vector products in Appendix B, and everywhere a vector product appears should be a scalar product. This affects Eqs. (B.5), (B.8), (B.10), (B.12), (B.13), and (B.20).

Equation (B.10), which defines one component of position within the plane of the galaxy, contains an additional typographical error, and it should have read

$$\xi = \mathbf{l} \cdot \mathbf{R} = \frac{l_x x + l_y y}{z + ax + by}. \quad (1)$$

Equation (B.21) is incorrect. The factor of $(ax + by + z)$ is applied to the wrong part of the equation. It should have read

$$(l_x - x(l_x x + l_y y))\dot{\xi} + (m_x - x(m_x x + m_y y + m_z z))\dot{\eta} \\ = -v_x + x(v_x x + v_y y + v_z z) + \dot{x}/(ax + by + z)$$

$$(l_y - y(l_x x + l_y y))\dot{\xi} + (m_y - y(m_x x + m_y y + m_z z))\dot{\eta} \\ = -v_y + y(v_x x + v_y y + v_z z) + \dot{y}/(ax + by + z). \quad (2)$$

This error affects the derived deprojected motions of stars in the LMC, and means that changes in the observational signature of

the bulk motion away from the centre are not properly accounted for. The effect becomes more significant further from the centre.

Figure 1 shows the resulting median tangential velocity, v_T (the rotation curve), and median radial velocity v_R as a function of de-projected radius R for the LMC, which is otherwise produced in the same way as before. The major differences between this and the equivalent figure in [Gaia Collaboration \(2018\)](#) are as follows

- The rotation curve reaches a greater velocity ($\sim 85 \text{ km s}^{-1}$ versus $\sim 75 \text{ km s}^{-1}$) and remains flat beyond 6 kpc, as opposed to starting to fall.
- The difference in asymmetric drift for the blue and red populations is clearer – the blue population, which is typically younger than the redder population, is rotating faster.
- The apparent outward motion of the stellar populations is much smaller. The blue population has almost no net radial motion, while the red population has one of $\lesssim 8 \text{ km s}^{-1}$ (as opposed to $\sim 20 \text{ km s}^{-1}$).
- The difference in radial motion between the $y < 0$ and $y > 0$ populations is dramatically reduced, as is the difference between the value derived assuming the known line-of-sight bulk motion and the one derived leaving this value free.

Acknowledgements. We are grateful to Eero Vaher, who pointed out the error in Eq. (B.10) and the vector products. This work presents results from the European Space Agency (ESA) space mission *Gaia*. *Gaia* data are being processed by the *Gaia* Data Processing and Analysis Consortium (DPAC). Funding for the DPAC is provided by national institutions, in particular the institutions participating in the *Gaia* MultiLateral Agreement (MLA). The *Gaia* mission website is <https://www.cosmos.esa.int/gaia>. The *Gaia* archive website is <https://archives.esac.esa.int/gaia>.

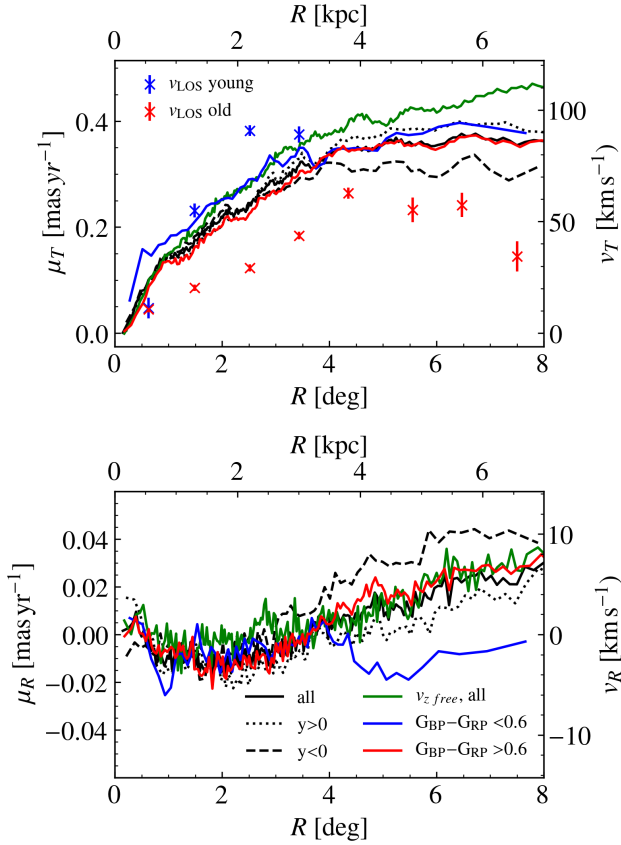


Fig. 1. Rotation curve (*top*) and median v_R (*bottom*) of the LMC, as a correction to Fig. 18 in Gaia Collaboration (2018). The assumed values for the centre-of-mass velocity and orientation of the disc (i and Ω) are taken from a fit to all stars within an angular radius $\rho < 3^\circ$ of the LMC's centre. Angular distances and velocities given on the lower and left axes have been converted to real-space values on the upper and right axes assuming a distance to the LMC of 50.1 kpc (Freedman et al. 2001). The points shown in the *upper panel* were derived from observed line-of-sight velocities of old and young stars by van der Marel & Kallivayalil (2014, their Table 4).

References

Freedman, W. L., Madore, B. F., Gibson, B. K., et al. 2001, *ApJ*, 553, 47
 Gaia Collaboration (Helmi, A., et al.) 2018, *A&A*, 616, A12
 van der Marel, R. P., & Kallivayalil, N. 2014, *ApJ*, 781, 121

- ¹ Kapteyn Astronomical Institute, University of Groningen, Landleven 12, 9747 AD Groningen, The Netherlands
e-mail: ahelmi@astro.rug.nl
- ² Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK
- ³ Lund Observatory, Department of Astronomy and Theoretical Physics, Lund University, Box 43, 22100 Lund, Sweden
- ⁴ Science Support Office, Directorate of Science, European Space Research and Technology Centre (ESA/ESTEC), Keplerlaan 1, 2201AZ, Noordwijk, The Netherlands
- ⁵ Institut de Ciències del Cosmos, Universitat de Barcelona (IEEC-UB), Martí i Franquès 1, 08028 Barcelona, Spain
- ⁶ Institut UTINAM UMR6213, CNRS, OSU THETA Franche-Comté Bourgogne, Université Bourgogne Franche-Comté, 25000 Besançon, France
- ⁷ Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Mönchhofstr. 12-14, 69120 Heidelberg, Germany

- ⁸ GEPI, Observatoire de Paris, Université PSL, CNRS, 5 Place Jules Janssen, 92190 Meudon, France
- ⁹ Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France
- ¹⁰ INAF – Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, 50125 Firenze, Italy
- ¹¹ Space Science Data Center – ASI, Via del Politecnico SNC, 00133 Roma, Italy
- ¹² Leiden Observatory, Leiden University, Niels Bohrweg 2, 2333 CA Leiden, The Netherlands
- ¹³ INAF – Osservatorio astronomico di Padova, Vicolo Osservatorio 5, 35122 Padova, Italy
- ¹⁴ Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg, Germany
- ¹⁵ Department of Astronomy, University of Geneva, Chemin des Maillettes 51, 1290 Versoix, Switzerland
- ¹⁶ Mission Operations Division, Operations Department, Directorate of Science, European Space Research and Technology Centre (ESA/ESTEC), Keplerlaan 1, 2201 AZ, Noordwijk, The Netherlands
- ¹⁷ Lohrmann Observatory, Technische Universität Dresden, Mommsenstraße 13, 01062 Dresden, Germany
- ¹⁸ European Space Astronomy Centre (ESA/ESAC), Camino bajo del Castillo, s/n, Urbanización Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ¹⁹ Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Bd de l'Observatoire, CS 34229, 06304 Nice Cedex 4, France
- ²⁰ CNES Centre Spatial de Toulouse, 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
- ²¹ Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles CP 226, Boulevard du Triomphe, 1050 Brussels, Belgium
- ²² F.R.S.-FNRS, Rue d'Egmont 5, 1000 Brussels, Belgium
- ²³ Telespazio Vega UK Ltd for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanización Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ²⁴ Laboratoire d'astrophysique de Bordeaux, Univ. Bordeaux, CNRS, B18N, allée Geoffroy Saint-Hilaire, 33615 Pessac, France
- ²⁵ Mullard Space Science Laboratory, University College London, Holmbury St Mary, Dorking, Surrey RH5 6NT, UK
- ²⁶ INAF – Osservatorio Astrofisico di Torino, Via Osservatorio 20, 10025 Pino Torinese (TO), Italy
- ²⁷ INAF – Osservatorio di Astrofisica e Scienza dello Spazio di Bologna, Via Piero Gobetti 93/3, 40129 Bologna, Italy
- ²⁸ Serco Gestión de Negocios for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanización Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ²⁹ ALTEC S.p.a, Corso Marche, 79,10146 Torino, Italy
- ³⁰ Department of Astronomy, University of Geneva, Chemin d'Ecogia 16, 1290 Versoix, Switzerland
- ³¹ Gaia DPAC Project Office, ESAC, Camino bajo del Castillo, s/n, Urbanización Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ³² SYRTE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, LNE, 61 avenue de l'Observatoire 75014 Paris, France
- ³³ National Observatory of Athens, I. Metaxa and Vas. Pavlou, Palaia Penteli, 15236 Athens, Greece
- ³⁴ IMCCE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Univ. Lille, 77 av. Denfert-Rochereau, 75014 Paris, France
- ³⁵ Royal Observatory of Belgium, Ringlaan 3, 1180 Brussels, Belgium
- ³⁶ Institut d'Astrophysique Spatiale, Université Paris XI, UMR 8617, CNRS, Bâtiment 121, 91405, Orsay Cedex, France
- ³⁷ Institute for Astronomy, University of Edinburgh, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, UK
- ³⁸ Instituut voor Sterrenkunde, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
- ³⁹ Institut d'Astrophysique et de Géophysique, Université de Liège, 19c, Allée du 6 Août, 4000 Liège, Belgium

- ⁴⁰ ATG Europe for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ⁴¹ Área de Lenguajes y Sistemas Informáticos, Universidad Pablo de Olavide, Ctra. de Utrera, km 1. 41013, Sevilla, Spain
- ⁴² ETSE Telecomunicación, Universidade de Vigo, Campus Lagoas-Marcosende, 36310 Vigo, Galicia, Spain
- ⁴³ Large Synoptic Survey Telescope, 950 N. Cherry Avenue, Tucson, AZ 85719, USA
- ⁴⁴ Observatoire Astronomique de Strasbourg, Université de Strasbourg, CNRS, UMR 7550, 11 rue de l'Université, 67000 Strasbourg, France
- ⁴⁵ Kavli Institute for Cosmology, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK
- ⁴⁶ Aurora Technology for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ⁴⁷ Laboratoire Univers et Particules de Montpellier, Université Montpellier, Place Eugène Bataillon, CC72, 34095 Montpellier Cedex 05, France
- ⁴⁸ Department of Physics and Astronomy, Division of Astronomy and Space Physics, Uppsala University, Box 516, 75120 Uppsala, Sweden
- ⁴⁹ CENTRA, Universidade de Lisboa, FCUL, Campo Grande, Edif. C8, 1749-016 Lisboa, Portugal
- ⁵⁰ Università di Catania, Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Via S. Sofia 78, 95123 Catania, Italy
- ⁵¹ INAF – Osservatorio Astrofisico di Catania, Via S. Sofia 78, 95123 Catania, Italy
- ⁵² University of Vienna, Department of Astrophysics, Türkenschanzstraße 17, A1180 Vienna, Austria
- ⁵³ CITIC – Department of Computer Science, University of A Coruña, Campus de Elviña s/n, 15071-, A Coruña, Spain
- ⁵⁴ CITIC – Astronomy and Astrophysics, University of A Coruña, Campus de Elviña s/n, 15071-, A Coruña, Spain
- ⁵⁵ INAF – Osservatorio Astronomico di Roma, Via di Frascati 33, 00078 Monte Porzio Catone (Roma), Italy
- ⁵⁶ University of Helsinki, Department of Physics, PO Box 64, 00014 Helsinki, Finland
- ⁵⁷ Finnish Geospatial Research Institute FGI, Geodeetinrinne 2, 02430 Masala, Finland
- ⁵⁸ Isdefe for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ⁵⁹ STFC, Rutherford Appleton Laboratory, Harwell, Didcot, OX11 0QX, UK
- ⁶⁰ Departamento de Inteligencia Artificial, UNED, c/ Juan del Rosal 16, 28040 Madrid, Spain
- ⁶¹ Elecnor Deimos Space for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ⁶² Thales Services for CNES Centre Spatial de Toulouse, 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
- ⁶³ Department of Astrophysics/IMAPP, Radboud University, PO Box 9010, 6500 GL Nijmegen, The Netherlands
- ⁶⁴ European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748 Garching, Germany
- ⁶⁵ ON/MCTI-BR, Rua Gal. José Cristino 77, Rio de Janeiro, CEP 20921-400, RJ, Brazil
- ⁶⁶ OV/UFRJ-BR, Ladeira Pedro Antônio 43, Rio de Janeiro, CEP 20080-090, RJ, Brazil
- ⁶⁷ Department of Terrestrial Magnetism, Carnegie Institution for Science, 5241 Broad Branch Road, NW, Washington, DC 20015-1305, USA
- ⁶⁸ Università di Torino, Dipartimento di Fisica, Via Pietro Giuria 1, 10125 Torino, Italy
- ⁶⁹ Departamento de Astrofísica, Centro de Astrobiología (CSIC-INTA), ESA-ESAC. Camino Bajo del Castillo s/n. 28692 Villanueva de la Cañada, Madrid, Spain
- ⁷⁰ Leicester Institute of Space and Earth Observation and Department of Physics and Astronomy, University of Leicester, University Road, Leicester LE1 7RH, UK
- ⁷¹ Departamento de Estadística, Universidad de Cádiz, Calle República Árabe Saharaui s/n. 11510, Puerto Real, Cádiz, Spain
- ⁷² Astronomical Institute Bern University, Sidlerstrasse 5, 3012 Bern, Switzerland (present address)
- ⁷³ EURIX S.r.l., Corso Vittorio Emanuele II 61, 10128 Torino, Italy
- ⁷⁴ Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge MA 02138, USA
- ⁷⁵ HE Space Operations BV for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ⁷⁶ SISSA – Scuola Internazionale Superiore di Studi Avanzati, Via Bonomea 265, 34136 Trieste, Italy
- ⁷⁷ University of Turin, Department of Computer Sciences, Corso Svizzera 185, 10149 Torino, Italy
- ⁷⁸ SRON, Netherlands Institute for Space Research, Sorbonnelaan 2, 3584CA, Utrecht, The Netherlands
- ⁷⁹ Departamento de Matemática Aplicada y Ciencias de la Computación, Univ. de Cantabria, ETS Ingenieros de Caminos, Canales y Puertos, Avda. de los Castros s/n, 39005 Santander, Spain
- ⁸⁰ Unidad de Astronomía, Universidad de Antofagasta, Avenida Angamos 601, Antofagasta 1270300, Chile
- ⁸¹ CRAAG – Centre de Recherche en Astronomie, Astrophysique et Géophysique, Route de l'Observatoire Bp 63 Bouzareah 16340 Algiers, Algeria
- ⁸² University of Antwerp, Onderzoeksgroep Toegepaste Wiskunde, Middelheimlaan 1, 2020 Antwerp, Belgium
- ⁸³ INAF – Osservatorio Astronomico d'Abruzzo, Via Mentore Maggini, 64100 Teramo, Italy
- ⁸⁴ INAF – Osservatorio Astronomico di Capodimonte, Via Moiriello 16, 80131 Napoli, Italy
- ⁸⁵ Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, Rua do Matão, 1226, Cidade Universitaria, 05508-900 São Paulo, SP, Brazil
- ⁸⁶ Department of Astrophysics, Astronomy and Mechanics, National and Kapodistrian University of Athens, Panepistimiopolis, Zografos, 15783 Athens, Greece
- ⁸⁷ Leibniz Institute for Astrophysics Potsdam (AIP), An der Sternwarte 16, 14482 Potsdam, Germany
- ⁸⁸ RHEA for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ⁸⁹ ATOS for CNES Centre Spatial de Toulouse, 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
- ⁹⁰ School of Physics and Astronomy, Tel Aviv University, Tel Aviv 6997801, Israel
- ⁹¹ UNINOVA – CTS, Campus FCT-UNL, Monte da Caparica, 2829-516 Caparica, Portugal
- ⁹² School of Physics, O'Brien Centre for Science North, University College Dublin, Belfield, Dublin 4, Ireland
- ⁹³ Dipartimento di Fisica e Astronomia, Università di Bologna, Via Piero Gobetti 93/2, 40129 Bologna, Italy
- ⁹⁴ Barcelona Supercomputing Center – Centro Nacional de Supercomputación, c/ Jordi Girona 29, Ed. Nexus II, 08034 Barcelona, Spain
- ⁹⁵ Department of Computer Science, Electrical and Space Engineering, Luleå University of Technology, Box 848, 981 28 Kiruna, Sweden
- ⁹⁶ Max Planck Institute for Extraterrestrial Physics, High Energy Group, Gießenbachstraße, 85741 Garching, Germany
- ⁹⁷ Astronomical Observatory Institute, Faculty of Physics, Adam Mickiewicz University, Słoneczna 36, 60-286 Poznań, Poland
- ⁹⁸ Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, Konkoly Thege Miklós út 15-17, 1121 Budapest, Hungary
- ⁹⁹ Eötvös Loránd University, Egyetem tér 1-3, 1053 Budapest, Hungary

- ¹⁰⁰ American Community Schools of Athens, 129 Aghias Paraskevis Ave. & Kazantzaki Street, Halandri, 15234 Athens, Greece
- ¹⁰¹ Faculty of Mathematics and Physics, University of Ljubljana, Jadranska ulica 19, 1000 Ljubljana, Slovenia
- ¹⁰² Villanova University, Department of Astrophysics and Planetary Science, 800 E Lancaster Avenue, Villanova PA 19085, USA
- ¹⁰³ Physics Department, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerp, Belgium
- ¹⁰⁴ McWilliams Center for Cosmology, Department of Physics, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, USA
- ¹⁰⁵ Astronomical Institute, Academy of Sciences of the Czech Republic, Fričova 298, 25165 Ondřejov, Czech Republic
- ¹⁰⁶ Telespazio for CNES Centre Spatial de Toulouse, 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
- ¹⁰⁷ Institut de Physique de Rennes, Université de Rennes 1, 35042 Rennes, France
- ¹⁰⁸ Shanghai Astronomical Observatory, Chinese Academy of Sciences, 80 Nandan Rd, 200030 Shanghai, PR China
- ¹⁰⁹ School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing 100049, PR China
- ¹¹⁰ Niels Bohr Institute, University of Copenhagen, Juliane Maries Vej 30, 2100 Copenhagen Ø, Denmark
- ¹¹¹ DXC Technology, Retortvej 8, 2500 Valby, Denmark
- ¹¹² Las Cumbres Observatory, 6740 Cortona Drive Suite 102, Goleta, CA 93117, USA
- ¹¹³ Astrophysics Research Institute, Liverpool John Moores University, 146 Brownlow Hill, Liverpool L3 5RF, UK
- ¹¹⁴ Baja Observatory of University of Szeged, Szegedi út III/70, 6500 Baja, Hungary
- ¹¹⁵ Laboratoire AIM, IRFU/Service d'Astrophysique – CEA/DSM – CNRS – Université Paris Diderot, Bât 709, CEA-Saclay, 91191 Gif-sur-Yvette Cedex, France
- ¹¹⁶ Warsaw University Observatory, Al. Ujazdowskie 4, 00-478 Warszawa, Poland
- ¹¹⁷ Institute of Theoretical Physics, Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic
- ¹¹⁸ AKKA for CNES Centre Spatial de Toulouse, 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
- ¹¹⁹ Vitrociset Belgium for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ¹²⁰ HE Space Operations BV for ESA/ESTEC, Keplerlaan 1, 2201AZ, Noordwijk, The Netherlands
- ¹²¹ Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
- ¹²² QUASAR Science Resources for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ¹²³ Fork Research, Rua do Cruzado Osberno, Lt. 1, 9 esq., Lisboa, Portugal
- ¹²⁴ APAVE SUDEUROPE SAS for CNES Centre Spatial de Toulouse, 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
- ¹²⁵ Nordic Optical Telescope, Rambla José Ana Fernández Pérez 7, 38711 Breña Baja, Spain
- ¹²⁶ Spanish Virtual Observatory, Spain
- ¹²⁷ Fundación Galileo Galilei – INAF, Rambla José Ana Fernández Pérez 7, 38712 Breña Baja, Santa Cruz de Tenerife, Spain
- ¹²⁸ INSA for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanizacion Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
- ¹²⁹ Departamento Arquitectura de Computadores y Automática, Facultad de Informática, Universidad Complutense de Madrid, C/ Prof. José García Santesmases s/n, 28040 Madrid, Spain
- ¹³⁰ H H Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8 1TL, UK
- ¹³¹ Institut d'Estudis Espacials de Catalunya (IEEC), Gran Capita 2-4, 08034 Barcelona, Spain
- ¹³² Applied Physics Department, Universidade de Vigo, 36310 Vigo, Spain
- ¹³³ Stellar Astrophysics Centre, Aarhus University, Department of Physics and Astronomy, 120 Ny Munkegade, Building 1520, 8000 Aarhus C, Denmark
- ¹³⁴ Argelander-Institut für Astronomie, Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany
- ¹³⁵ Research School of Astronomy and Astrophysics, Australian National University, Canberra, ACT 2611 Australia
- ¹³⁶ Sorbonne Universités, UPMC Univ. Paris 6 et CNRS, UMR 7095, Institut d'Astrophysique de Paris, 98 bis bd. Arago, 75014 Paris, France
- ¹³⁷ Department of Geosciences, Tel Aviv University, Tel Aviv 6997801, Israel