Proj_Ceph_07525268

November 16, 2023

[ ]:

```

```

[2]:

```
import numpy as np
import matplotlib.pyplot as plt
from astropy.io import ascii
from astropy.io import fits
```

Table 3: Sample MW data

[58]:

```
hdus=fits.open("table3.dat.fits")
print(hdus.info())
print(hdus["PRIMARY"].header.items)
print(hdus["table3.dat"].header.items)
#print(hdus["table3.dat"].data.shape)
#hdus.verify("fix")
data=hdus[1].data
print(data[0].field(0))
print(data[0].field(7))
print('Per:', data[0].field('Per'), 'parallax:', data[0].field('plx'),'fe/h:',␣
  ↪data[0].field('[Fe/H]'))
hdus.close()
```

```
Filename: table3.dat.fits
No.    Name      Ver    Type      Cards   Dimensions   Format
  0  PRIMARY       1 PrimaryHDU     118   ()
  1  table3.dat    1 TableHDU        93   188R x 11C   [A11, F6.3, F5.3, F5.3,
F4.2, F5.3, F5.3, A3, F5.2, F4.2, A4]
None
<bound method Header.items of SIMPLE  =                    T / Standard FITS
Format
BITPIX  =                    8 / Character data
NAXIS   =                    0 / No Image --- just extension(s)
EXTEND  =                    T / There are standard extensions
ORIGIN  = 'CDS     '           / File generated at CDS, Strasbourg, France
                                 (tofits, Version 3.4)
             e-mail:    question@simbad.u-strasbg.fr
COMMENT  ARG='-m -1 /ftp/cats/J/ApJ/913/38/./table3.dat'
LONGSTRN= 'OGIP 1.0'           / Long string convention (&/CONTINUE) may be used
DATE    = '2023-10-12'         / Written on 2023-10-12:13:12:01 (GMT)
```

```
                              by: www-data@cdsarc.astro.unistra.fr
CDS-CAT = 'J/ApJ/913/38'       / Catalogue designation in CDS nomenclature
COMMENT  Compilation of Cepheids in the MW and MCs (Breuval+, 2021)
COMMENT  Title:  The influence of metallicity on the Leavitt law from
                 geometrical distances of Milky Way and Magellanic Cloud
                 Cepheids.
AUTHOR  = 'Breuval L., Kervella P., Wielgorski P., Gieren W., Graczyk D., Trah&'
CONTINUE  'in B.,&'
CONTINUE  'Pietrzynski G., Arenou F., Javanmardi B., Zgirski B.'
REFERENC= 'Astrophys. J., 913, 38-38 (2021)'
BIBCODE = '2021ApJ…913…38B' / 19-digit SIMBAD/NED/ADS BibCode
COMMENT  ADC_Keywords: Stars, variable; Photometry, UBVRI; Stars, distances;
         Milky Way;
         Abundances, [Fe/H]; Parallaxes, trigonometric; Magellanic Clouds
COMMENT  Keywords: Cepheid distance; Parallax; Metallicity; Magellanic Clouds
         Milky Way Galaxy
COMMENT  Abstract:
         The Cepheid period-luminosity (PL) relation is the key tool for
         measuring astronomical distances and for establishing the
         extragalactic distance scale. In particular, the local value of the
         Hubble constant (H_0_) strongly depends on Cepheid distance
         measurements. The recent Gaia Data Releases and other parallax
         measurements from the Hubble Space Telescope (HST) already enabled us
         to improve the accuracy of the slope ({alpha}) and intercept ({beta})
         of the PL relation. However, the dependence of this law on metallicity
         is still largely debated. In this paper, we combine three samples of
         Cepheids in the Milky Way (MW), the Large Magellanic Cloud (LMC), and
         the Small Magellanic Cloud (SMC) in order to derive the metallicity
         term (hereafter {gamma}) of the PL relation. The recent publication of
         extremely precise LMC and SMC distances based on late-type detached
         eclipsing binary systems provides a solid anchor for the Magellanic
         Clouds. In the MW, we adopt Cepheid parallaxes from the early third
         Gaia Data Release. We derive the metallicity effect in V, I, J, H,
         K_S_, W_VI_, and W_JK_. In the K_S_ band we report a metallicity
         effect of -0.221+/-0.051mag/dex, the negative sign meaning that more
         metal-rich Cepheids are intrinsically brighter than their more
         metal-poor counterparts of the same pulsation period.
COMMENT  File Summary:
         ----------------------------------------------------------------------
          FileName        Lrecl  Records   Explanations
         ----------------------------------------------------------------------
          ReadMe             80        .    This file
          table3.dat         67      188    Sample of Milky Way Cepheids and
         main parameters
          table4.dat         92      222    Optical and NIR mean apparent
         magnitudes for
                                        the sample of Milky Way Cepheids
          table5.dat        131     1519    Sample of Large Magellanic Cloud
```

```
        Cepheids and
                                      their main parameters
         table6.dat        131      300    Sample of Small Magellanic Cloud
        Cepheids and
                                      their main parameters
        ----------------------------------------------------------------------
COMMENT See also:
        B/vsx  : AAVSO International Variable Star Index VSX (Watson+, 2006-)
        II/246 : 2MASS All-Sky Catalog of Point Sources (Cutri+ 2003)
        II/285 : Photoelectric observations of Cepheids in UBV(RI)c
        (Berdnikov, 2008)
        I/350  : Gaia EDR3 (Gaia Collaboration, 2020)
        J/AcA/49/543  : OGLE LMC & SMC Cepheids VI photometry (Pietrzynski+,
        1999)
        J/AcA/51/221  : OGLE-II. Cepheids in IC 1613 (Udalski+, 2001)
        J/AJ/128/2239 : JHKs photometry of 92 LMC Cepheids (Persson+, 2004)
        J/ApJ/652/1133   : BVI photometry of NGC 4258 Cepheids (Macri+, 2006)
        J/MNRAS/386/2115 : Type II Cepheid and RR Lyrae variables (Feast+,
        2008)
        J/AcA/58/313  : LMC Cepheids in OGLE and MACHO data (Poleski+, 2008)
        J/ApJS/193/12 : JHK photometry of Northern Galactic Cepheids (Monson+,
        2011)
        J/AJ/142/51   : Galactic Cepheids abundance variations (Luck+, 2011)
        J/A+A/534/A94 : Milky Way Cepheids radial velocities (Storm+, 2011)
        J/A+A/534/A95 : LMC Cepheids radial velocities (Storm+, 2011)
        J/AJ/142/136  : Spectroscopy of Cepheids. l=30-250{deg} (Luck+, 2011)
        J/MNRAS/420/1590 : Abundances of classical Cepheids (Acharova+, 2012)
        J/A+A/554/A132   : Iron line list (FeI and FeII) (Genovali+, 2013)
        J/A+A/566/A37 : Iron abundances for 42 Galactic Cepheids (Genovali+,
        2014)
        J/AcA/65/233  : OGLE Magellanic Clouds anomalous Cepheids (Soszynski+,
        2015)
        J/AJ/149/117  : LMC infrared survey. I. Photometry of Cepheids
        (Macri+, 2015)
        J/A+A/580/A17 : {alpha}-element abundances of Cepheid stars
        (Genovali+, 2015)
        J/ApJS/224/21 : The VMC survey. XIX. Classical Cepheids in SMC
        (Ripepi+, 2016)
        J/ApJ/826/56  : HST/WFC3 obs. of Cepheids in SN Ia host gal. (Riess+,
        2016)
        J/ApJ/832/176 : Classical Cepheids in MCs. I. LMC disk (Inno+, 2016)
        J/ApJ/842/42  : Improved reddenings for 59 Galactic Cepheids (Madore+,
        2017)
        J/MNRAS/472/808 : YJKs light curves of SMC Classical Cepheids
        (Ripepi+, 2017)
        J/AJ/156/171  : Cepheid abundances (Luck, 2018)
        J/A+A/619/A8  : Cepheid PL-metallicity relation (Groenewegen, 2018)
        J/A+A/620/A99 : SMC Cepheids K-band and RV curves (Gieren+, 2018)
```

```
        J/A+A/623/A72 : Binarity of HIP stars from Gaia pm anomaly (Kervella+,
        2019)
        J/A+A/625/A14 : Reclassification of Cepheids in the Gaia DR2 (Ripepi+,
        2019)
        J/ApJ/876/85  : HST observations for LMC Cepheids (Riess+, 2019)
        J/ApJ/911/12  : HST opt-NIR obs. of Cepheids in NGC5584 (Javanmardi+,
        2021)
COMMENT  Unused Described file:  table3.dat
COMMENT  Unused Described file:  table4.dat
COMMENT  Unused Described file:  table[56].dat
COMMENT  History:
         From electronic version of the journal
         ======================================================================
HISTORY  (End) Prepared by [AAS], Emmanuelle Perret [CDS] 25-Nov-2022
>
<bound method Header.items of XTENSION= 'TABLE   '           / Ascii Table
Extension
BITPIX  =                    8 / Character data
NAXIS   =                    2 / Simple 2-D matrix
NAXIS1  =                   67 / Number of bytes per record
NAXIS2  =                  188 / Number of records
PCOUNT  =                    0 / Get rid of random parameters
GCOUNT  =                    1 / Only one group (isn't it obvious?)
TFIELDS =                   11 / Number of data fields (columns)
EXTNAME = 'table3.dat'         / Sample of Milky Way Cepheids and main
                                 parameters
         ======================================================================
TBCOL1  =                    1 / ============== Start column +0
TFORM1  = 'A11     '           / Fortran Format
TTYPE1  = 'Name    '           / Cepheid identifier
TBCOL2  =                   13 / ============== Start column +12
TUNIT2  = 'd       '           / Unit: day
TFORM2  = 'F6.3    '           / Fortran Format
TDISP2  = 'F6.3    '           / Display Format for Binary Tables
TTYPE2  = 'Per     '           / [2.7/51.8] Period
TAMIN2  =                2.700 / Allowed minimal value
TAMAX2  =               51.800 / Allowed maximal value
TBCOL3  =                   20 / ============== Start column +19
TUNIT3  = 'mas     '           / Unit: milli-second of arc
TFORM3  = 'F5.3    '           / Fortran Format
TDISP3  = 'F5.3    '           / Display Format for Binary Tables
TTYPE3  = 'plx     '           / [0.1/2.9] Gaia EDR3 parallax (includes zero
                                 point correction)
TAMIN3  =                0.100 / Allowed minimal value
TAMAX3  =                2.900 / Allowed maximal value
TBCOL4  =                   26 / ============== Start column +25
TUNIT4  = 'mas     '           / Unit: milli-second of arc
TFORM4  = 'F5.3    '           / Fortran Format
```

```
TDISP4  = 'F5.3    '           / Display Format for Binary Tables
TTYPE4  = 'e_plx   '           / [0.01/0.15] Uncertainty in plx
TAMIN4  =                0.010 / Allowed minimal value
TAMAX4  =                0.150 / Allowed maximal value
TBCOL5  =                   32 / ============== Start column +31
TFORM5  = 'F4.2    '           / Fortran Format
TDISP5  = 'F4.2    '           / Display Format for Binary Tables
TTYPE5  = 'RUWE    '           / [0.7/1.4] Renormalised Unit Weight Error
TAMIN5  =                 0.70 / Allowed minimal value
TAMAX5  =                 1.40 / Allowed maximal value
TBCOL6  =                   37 / ============== Start column +36
TUNIT6  = 'mag     '           / Unit: magnitude
TFORM6  = 'F5.3    '           / Fortran Format
TDISP6  = 'F5.3    '           / Display Format for Binary Tables
TTYPE6  = 'E(B-V)  '           / [0.086/1.55] The (B-V) color excess
TAMIN6  =                0.086 / Allowed minimal value
TAMAX6  =                1.550 / Allowed maximal value
TBCOL7  =                   43 / ============== Start column +42
TUNIT7  = 'mag     '           / Unit: magnitude
TFORM7  = 'F5.3    '           / Fortran Format
TDISP7  = 'F5.3    '           / Display Format for Binary Tables
TTYPE7  = 'e_E(B-V)'           / [0.003/0.25] Uncertainty in E(B-V)
TAMIN7  =                0.003 / Allowed minimal value
TAMAX7  =                0.250 / Allowed maximal value
TBCOL8  =                   49 / ============== Start column +48
TFORM8  = 'A3      '           / Fortran Format
TTYPE8  = 'r_E(B-V)'           / Reference code for E(B-V) (1)
TBCOL9  =                   53 / ============== Start column +52
TUNIT9  = '[Sun]   '           / Unit: log[ Solar unit ]
TFORM9  = 'F5.2    '           / Fortran Format
TDISP9  = 'F5.2    '           / Display Format for Binary Tables
TTYPE9  = '[Fe/H]  '           / [-0.33/0.55] Metallicity
TAMIN9  =                -0.33 / Allowed minimal value
TAMAX9  =                 0.55 / Allowed maximal value
TBCOL10 =                   59 / ============== Start column +58
TUNIT10 = '[Sun]   '           / Unit: log[ Solar unit ]
TFORM10 = 'F4.2    '           / Fortran Format
TDISP10 = 'F4.2    '           / Display Format for Binary Tables
TTYPE10 = 'e_[Fe/H]'           / [0.03/0.3] Uncertainty in [Fe/H]
TAMIN10 =                 0.03 / Allowed minimal value
TAMAX10 =                 0.30 / Allowed maximal value
TBCOL11 =                   64 / ============== Start column +63
TFORM11 = 'A4      '           / Fortran Format
TTYPE11 = 'r_[Fe/H]'           / Reference code for [Fe/H] (1)
          ======================================================================
COMMENT   Note (1): E(B-V) and [Fe/H] reference code as follows:
           A12 = Acharova et al. (2012, J/MNRAS/420/1590)
           F95 = Fernie et al. (1995IBVS.4148…1F) multiplied by 0.94.
```

```
          G14 = Genovali et al. (2014, J/A+A/566/A37).
         G14b = from the literature (
                Genovali et al. (2013, J/A+A/554/A132);
                Lemasle et al. (2007A&A…467..283L);
                Luck et al. (2011, J/AJ/156/171);
                Luck & Lambert (2011, J/AJ/142/136);
                Pedicelli et al. (2010A&A…518A..11P);
                Romaniello et al. (2008A&A…448..731R);
                Sziladi et al. (2007A&A…473..579S);
                Yong et al. (2006AJ…131.2256Y)
                ) rescaled to Genovali+ (2014, J/A+A/566/A37) solar abundance.
          G15 = Genovali et al. (2015, J/A+A/580/A17).
========================================================================>
AA Gem
F95
Per: 11.302 parallax: 0.311 fe/h: -0.08
```

[53]:

```
# Read in the data with astropy.io.ascii
#tbl = ascii.read("table3.dat")
#tbl
```

[ ]:

```
```

[57]:

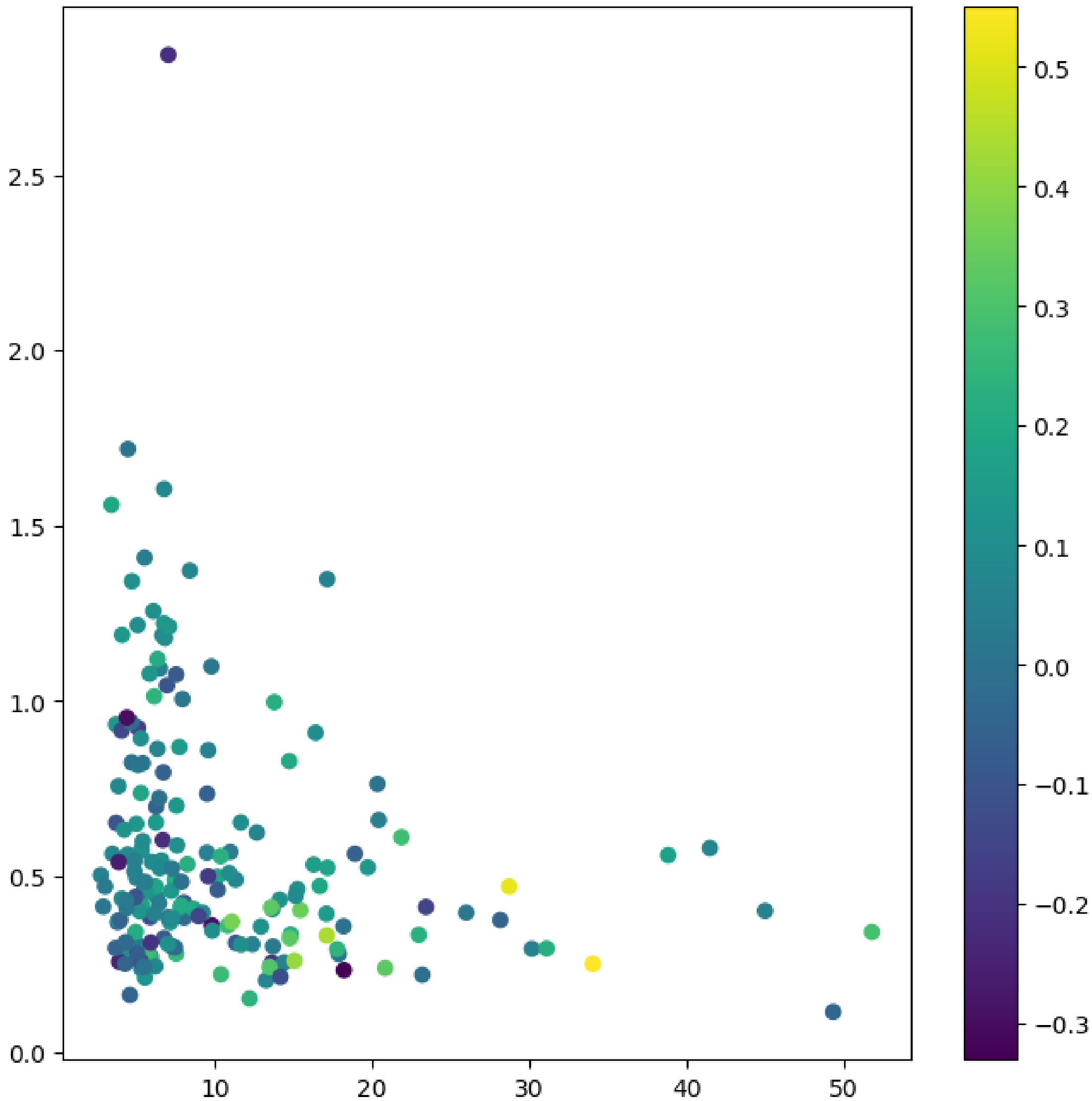
```
# Scatter plot of table 3 period / mas  / metallicity
#plt.figure(figsize=(8,8))
#plt.scatter(x=tbl["col3"], y=tbl["col4"], c=tbl["col10"])
#plt.colorbar()
```

[59]:

```
# Scatter plot of table 3 period / mas  / metallicity from fits
plt.figure(figsize=(8,8))
plt.scatter(x=data["Per"], y=data["plx"], c=data["[Fe/H]"])
plt.colorbar()
```

[59]:

```
<matplotlib.colorbar.Colorbar at 0x1d36fdaa050>
```



[60]:
```python
# Histogram of table 3 Fe/H column density
_ = plt.hist(data["[Fe/H]"], bins=50)
```

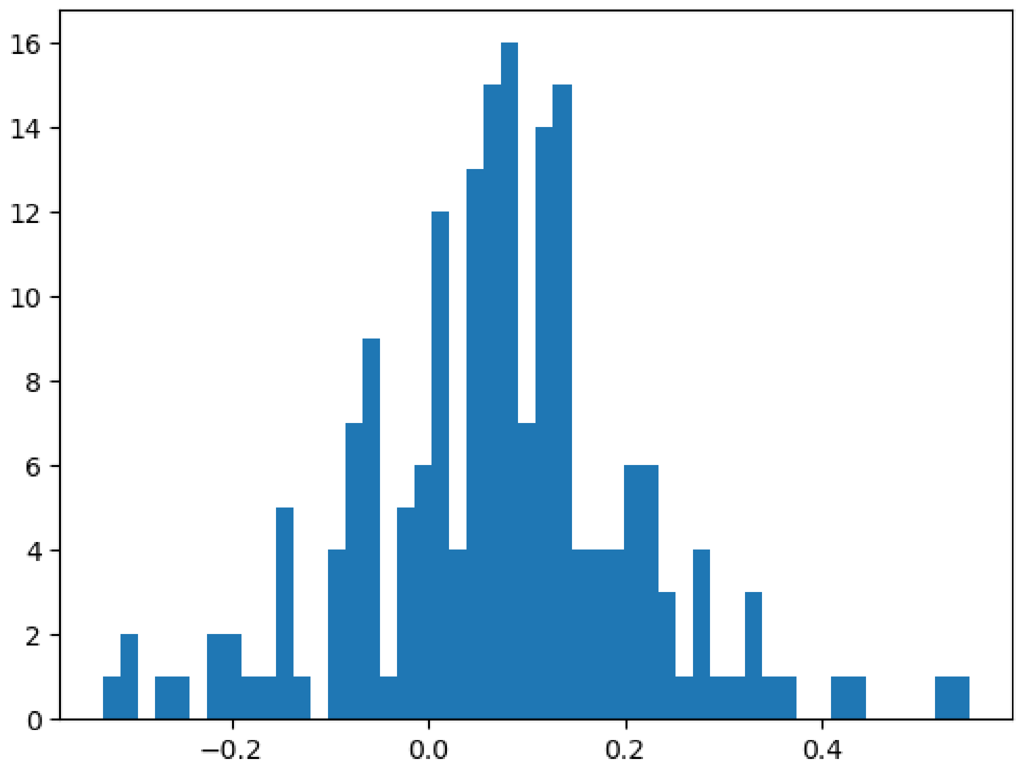


Table 4: OPT, NIR of MW

[62]:
```
hdus=fits.open("table4.dat.fits")
print(hdus.info())
print(hdus["PRIMARY"].header.items)
print(hdus["table4.dat"].header.items)
#print(hdus["table4.dat"].data.shape)
#hdus.verify("fix")
data=hdus[1].data
print(data[0].field(0))
print(data[0].field(7))
print('Vmag:', data[0].field('Vmag'), 'Imag:', data[0].field('Imag'),'Ks mag:',␣
 ↪data[0].field('Ksmag'))
hdus.close()
```

```
Filename: table4.dat.fits
No.    Name      Ver    Type      Cards   Dimensions   Format
  0  PRIMARY       1 PrimaryHDU     118   ()
  1  table4.dat    1 TableHDU       115   222R x 12C   [A11, F6.3, F5.3, F6.3,
F5.3, F5.3, F5.3, F5.3, F5.3, F5.3, F5.3, A18]
None
<bound method Header.items of SIMPLE  =                    T / Standard FITS
Format
```

```
BITPIX  =                    8 / Character data
NAXIS   =                    0 / No Image --- just extension(s)
EXTEND  =                    T / There are standard extensions
ORIGIN  = 'CDS     '           / File generated at CDS, Strasbourg, France
                                 (tofits, Version 3.4)
             e-mail:    question@simbad.u-strasbg.fr
COMMENT  ARG='-m -1 /ftp/cats/J/ApJ/913/38/./table4.dat'
LONGSTRN= 'OGIP 1.0'           / Long string convention (&/CONTINUE) may be used
DATE    = '2023-10-12'         / Written on 2023-10-12:13:12:07 (GMT)
                             by: www-data@cdsarc.astro.unistra.fr
CDS-CAT = 'J/ApJ/913/38'       / Catalogue designation in CDS nomenclature
COMMENT  Compilation of Cepheids in the MW and MCs (Breuval+, 2021)
COMMENT  Title:  The influence of metallicity on the Leavitt law from
                 geometrical distances of Milky Way and Magellanic Cloud
                 Cepheids.
AUTHOR  = 'Breuval L., Kervella P., Wielgorski P., Gieren W., Graczyk D., Trah&'
CONTINUE  'in B.,&'
CONTINUE  'Pietrzynski G., Arenou F., Javanmardi B., Zgirski B.'
REFERENC= 'Astrophys. J., 913, 38-38 (2021)'
BIBCODE = '2021ApJ…913…38B' / 19-digit SIMBAD/NED/ADS BibCode
COMMENT  ADC_Keywords: Stars, variable; Photometry, UBVRI; Stars, distances;
         Milky Way;
         Abundances, [Fe/H]; Parallaxes, trigonometric; Magellanic Clouds
COMMENT  Keywords: Cepheid distance; Parallax; Metallicity; Magellanic Clouds
         Milky Way Galaxy
COMMENT  Abstract:
         The Cepheid period-luminosity (PL) relation is the key tool for
         measuring astronomical distances and for establishing the
         extragalactic distance scale. In particular, the local value of the
         Hubble constant (H_0_) strongly depends on Cepheid distance
         measurements. The recent Gaia Data Releases and other parallax
         measurements from the Hubble Space Telescope (HST) already enabled us
         to improve the accuracy of the slope ({alpha}) and intercept ({beta})
         of the PL relation. However, the dependence of this law on metallicity
         is still largely debated. In this paper, we combine three samples of
         Cepheids in the Milky Way (MW), the Large Magellanic Cloud (LMC), and
         the Small Magellanic Cloud (SMC) in order to derive the metallicity
         term (hereafter {gamma}) of the PL relation. The recent publication of
         extremely precise LMC and SMC distances based on late-type detached
         eclipsing binary systems provides a solid anchor for the Magellanic
         Clouds. In the MW, we adopt Cepheid parallaxes from the early third
         Gaia Data Release. We derive the metallicity effect in V, I, J, H,
         K_S_, W_VI_, and W_JK_. In the K_S_ band we report a metallicity
         effect of -0.221+/-0.051mag/dex, the negative sign meaning that more
         metal-rich Cepheids are intrinsically brighter than their more
         metal-poor counterparts of the same pulsation period.
COMMENT  File Summary:
         ----------------------------------------------------------------------
```

```
 FileName        Lrecl  Records   Explanations
--------------------------------------------------------------------------------
 ReadMe             80        .    This file
 table3.dat         67      188    Sample of Milky Way Cepheids and
main parameters
 table4.dat         92      222    Optical and NIR mean apparent
magnitudes for
                               the sample of Milky Way Cepheids
 table5.dat        131     1519    Sample of Large Magellanic Cloud
Cepheids and
                               their main parameters
 table6.dat        131      300    Sample of Small Magellanic Cloud
Cepheids and
                               their main parameters
--------------------------------------------------------------------------------
```

```
COMMENT  See also:
         B/vsx  : AAVSO International Variable Star Index VSX (Watson+, 2006-)
         II/246 : 2MASS All-Sky Catalog of Point Sources (Cutri+ 2003)
         II/285 : Photoelectric observations of Cepheids in UBV(RI)c
         (Berdnikov, 2008)
         I/350  : Gaia EDR3 (Gaia Collaboration, 2020)
         J/AcA/49/543  : OGLE LMC & SMC Cepheids VI photometry (Pietrzynski+,
         1999)
         J/AcA/51/221  : OGLE-II. Cepheids in IC 1613 (Udalski+, 2001)
         J/AJ/128/2239 : JHKs photometry of 92 LMC Cepheids (Persson+, 2004)
         J/ApJ/652/1133   : BVI photometry of NGC 4258 Cepheids (Macri+, 2006)
         J/MNRAS/386/2115 : Type II Cepheid and RR Lyrae variables (Feast+,
         2008)
         J/AcA/58/313  : LMC Cepheids in OGLE and MACHO data (Poleski+, 2008)
         J/ApJS/193/12 : JHK photometry of Northern Galactic Cepheids (Monson+,
         2011)
         J/AJ/142/51   : Galactic Cepheids abundance variations (Luck+, 2011)
         J/A+A/534/A94 : Milky Way Cepheids radial velocities (Storm+, 2011)
         J/A+A/534/A95 : LMC Cepheids radial velocities (Storm+, 2011)
         J/AJ/142/136  : Spectroscopy of Cepheids. l=30-250{deg} (Luck+, 2011)
         J/MNRAS/420/1590 : Abundances of classical Cepheids (Acharova+, 2012)
         J/A+A/554/A132   : Iron line list (FeI and FeII) (Genovali+, 2013)
         J/A+A/566/A37 : Iron abundances for 42 Galactic Cepheids (Genovali+,
         2014)
         J/AcA/65/233  : OGLE Magellanic Clouds anomalous Cepheids (Soszynski+,
         2015)
         J/AJ/149/117  : LMC infrared survey. I. Photometry of Cepheids
         (Macri+, 2015)
         J/A+A/580/A17 : {alpha}-element abundances of Cepheid stars
         (Genovali+, 2015)
         J/ApJS/224/21 : The VMC survey. XIX. Classical Cepheids in SMC
         (Ripepi+, 2016)
         J/ApJ/826/56  : HST/WFC3 obs. of Cepheids in SN Ia host gal. (Riess+,
```

```
        2016)
        J/ApJ/832/176 : Classical Cepheids in MCs. I. LMC disk (Inno+, 2016)
        J/ApJ/842/42  : Improved reddenings for 59 Galactic Cepheids (Madore+,
        2017)
        J/MNRAS/472/808 : YJKs light curves of SMC Classical Cepheids
        (Ripepi+, 2017)
        J/AJ/156/171  : Cepheid abundances (Luck, 2018)
        J/A+A/619/A8  : Cepheid PL-metallicity relation (Groenewegen, 2018)
        J/A+A/620/A99 : SMC Cepheids K-band and RV curves (Gieren+, 2018)
        J/A+A/623/A72 : Binarity of HIP stars from Gaia pm anomaly (Kervella+,
        2019)
        J/A+A/625/A14 : Reclassification of Cepheids in the Gaia DR2 (Ripepi+,
        2019)
        J/ApJ/876/85  : HST observations for LMC Cepheids (Riess+, 2019)
        J/ApJ/911/12  : HST opt-NIR obs. of Cepheids in NGC5584 (Javanmardi+,
        2021)
COMMENT  Unused Described file:  table3.dat
COMMENT  Unused Described file:  table4.dat
COMMENT  Unused Described file:  table[56].dat
COMMENT  History:
        From electronic version of the journal
        ================================================================
HISTORY  (End) Prepared by [AAS], Emmanuelle Perret [CDS] 25-Nov-2022
>
<bound method Header.items of XTENSION= 'TABLE   '           / Ascii Table
Extension
BITPIX  =                    8 / Character data
NAXIS   =                    2 / Simple 2-D matrix
NAXIS1  =                   92 / Number of bytes per record
NAXIS2  =                  222 / Number of records
PCOUNT  =                    0 / Get rid of random parameters
GCOUNT  =                    1 / Only one group (isn't it obvious?)
TFIELDS =                   12 / Number of data fields (columns)
EXTNAME = 'table4.dat'         / Optical and NIR mean apparent magnitudes for
                                 the sample of Milky Way Cepheids
        ================================================================
TBCOL1  =                    1 / ============= Start column +0
TFORM1  = 'A11     '           / Fortran Format
TTYPE1  = 'Name    '           / Cepheid identifier
TBCOL2  =                   13 / ============= Start column +12
TUNIT2  = 'mag     '           / Unit: magnitude
TFORM2  = 'F6.3    '           / Fortran Format
TDISP2  = 'F6.3    '           / Display Format for Binary Tables
TTYPE2  = 'Vmag    '           / [3.7/11.92]? Mean apparent V band magnitude
                                 without reddening correction (2)
TAMIN2  =                3.700 / Allowed minimal value
TAMAX2  =               11.920 / Allowed maximal value
TBNUL2  = '        '           / NULL (undefined) value
```

```
TBCOL3  =                   20 / ============== Start column +19
TUNIT3  = 'mag     '           / Unit: magnitude
TFORM3  = 'F5.3    '           / Fortran Format
TDISP3  = 'F5.3    '           / Display Format for Binary Tables
TTYPE3  = 'e_Vmag  '           / [0.006/0.3]? Uncertainty in Vmag (3)
TAMIN3  =                0.006 / Allowed minimal value
TAMAX3  =                0.300 / Allowed maximal value
TBNUL3  = '        '           / NULL (undefined) value
TBCOL4  =                   26 / ============== Start column +25
TUNIT4  = 'mag     '           / Unit: magnitude
TFORM4  = 'F6.3    '           / Fortran Format
TDISP4  = 'F6.3    '           / Display Format for Binary Tables
TTYPE4  = 'Imag    '           / [2.5/10.6]? Mean apparent I band magnitude
                                 without reddening correction (2)
TAMIN4  =                2.500 / Allowed minimal value
TAMAX4  =               10.600 / Allowed maximal value
TBNUL4  = '        '           / NULL (undefined) value
TBCOL5  =                   33 / ============== Start column +32
TUNIT5  = 'mag     '           / Unit: magnitude
TFORM5  = 'F5.3    '           / Fortran Format
TDISP5  = 'F5.3    '           / Display Format for Binary Tables
TTYPE5  = 'e_Imag  '           / [0.006/0.05]? Uncertainty in Imag (3)
TAMIN5  =                0.006 / Allowed minimal value
TAMAX5  =                0.050 / Allowed maximal value
TBNUL5  = '        '           / NULL (undefined) value
TBCOL6  =                   39 / ============== Start column +38
TUNIT6  = 'mag     '           / Unit: magnitude
TFORM6  = 'F5.3    '           / Fortran Format
TDISP6  = 'F5.3    '           / Display Format for Binary Tables
TTYPE6  = 'Jmag    '           / [1.67/9.35]? Mean apparent H band magnitude
                                 without reddening correction
TAMIN6  =                1.670 / Allowed minimal value
TAMAX6  =                9.350 / Allowed maximal value
TBNUL6  = '        '           / NULL (undefined) value
TBCOL7  =                   45 / ============== Start column +44
TUNIT7  = 'mag     '           / Unit: magnitude
TFORM7  = 'F5.3    '           / Fortran Format
TDISP7  = 'F5.3    '           / Display Format for Binary Tables
TTYPE7  = 'e_Jmag  '           / [0.006/0.04]? Uncertainty in Jmag (3)
TAMIN7  =                0.006 / Allowed minimal value
TAMAX7  =                0.040 / Allowed maximal value
TBNUL7  = '        '           / NULL (undefined) value
TBCOL8  =                   51 / ============== Start column +50
TUNIT8  = 'mag     '           / Unit: magnitude
TFORM8  = 'F5.3    '           / Fortran Format
TDISP8  = 'F5.3    '           / Display Format for Binary Tables
TTYPE8  = 'Hmag    '           / [1.21/8.96]? Mean apparent H band magnitude
                                 without reddening correction
```

```
TAMIN8  =                1.210 / Allowed minimal value
TAMAX8  =                8.960 / Allowed maximal value
TBNUL8  = '        '           / NULL (undefined) value
TBCOL9  =                   57 / ============== Start column +56
TUNIT9  = 'mag     '           / Unit: magnitude
TFORM9  = 'F5.3    '           / Fortran Format
TDISP9  = 'F5.3    '           / Display Format for Binary Tables
TTYPE9  = 'e_Hmag  '           / [0.006/0.03]? Uncertainty in Hmag (3)
TAMIN9  =                0.006 / Allowed minimal value
TAMAX9  =                0.030 / Allowed maximal value
TBNUL9  = '        '           / NULL (undefined) value
TBCOL10 =                   63 / ============== Start column +62
TUNIT10 = 'mag     '           / Unit: magnitude
TFORM10 = 'F5.3    '           / Fortran Format
TDISP10 = 'F5.3    '           / Display Format for Binary Tables
TTYPE10 = 'Ksmag   '           / [1.05/8.81]? Mean apparent Ks band magnitude
                                 without reddening correction
TAMIN10 =                1.050 / Allowed minimal value
TAMAX10 =                8.810 / Allowed maximal value
TBNUL10 = '        '           / NULL (undefined) value
TBCOL11 =                   69 / ============== Start column +68
TUNIT11 = 'mag     '           / Unit: magnitude
TFORM11 = 'F5.3    '           / Fortran Format
TDISP11 = 'F5.3    '           / Display Format for Binary Tables
TTYPE11 = 'e_Ksmag '           / [0.006/0.03]? Uncertainty in Ksmag (3)
TAMIN11 =                0.006 / Allowed minimal value
TAMAX11 =                0.030 / Allowed maximal value
TBNUL11 = '        '           / NULL (undefined) value
TBCOL12 =                   75 / ============== Start column +74
TFORM12 = 'A18     '           / Fortran Format
TTYPE12 = 'NIR     '           / NIR reference code (s) (4)
          ==================================================================
COMMENT   Note (2): Johnson-Cousins V and I magnitudes from Berdnikov (2008, Cat.
          II/285)
COMMENT   Note (3): The uncertainties are only the random errors and do not
          include
          photometric zero point errors.
COMMENT   Note (4): NIR reference code as follows:
          B97 = Barnes et al. (1997PASP..109..645B)
          F08 = Feast et al. (2008, J/MNRAS/386/2115)
          L92 = Laney & Stobie (1992A&AS…93…93L)
          M11 = Monson & Pierce (2011, J/ApJS/193/12)
          W84 = Welch et al. (1984ApJS…54..547W)
=================================================================>
AA Gem
7.206
Vmag: 9.735 Imag: 0.0 Ks mag: 7.069
```

Table 5 LMC

[63]:
```
hdus=fits.open("table5.dat.fits")
print(hdus.info())
print(hdus["PRIMARY"].header.items)
print(hdus["table5.dat"].header.items)
#print(hdus["table5.dat"].data.shape)
#hdus.verify("fix")
data=hdus[1].data
print(data[0].field(0))
print(data[0].field(7))
print('Per:', data[0].field('Per'), 'Dist:', data[0].field('Dist'),'Ks:',␣
↪data[0].field('Ksmag'))
hdus.close()
```

```
Filename: table5.dat.fits
No.    Name      Ver    Type      Cards   Dimensions   Format
  0  PRIMARY       1 PrimaryHDU     118   ()
  1  table5.dat    1 TableHDU       153   1519R x 18C   [A17, F6.3, F7.4, F8.4,
F7.4, F6.4, F6.3, F4.2, F6.3, F4.2, F6.3, F5.3, F6.3, F5.3, F6.3, F5.3, F5.3,
F5.3]
None
<bound method Header.items of SIMPLE  =                    T / Standard FITS
Format
BITPIX  =                    8 / Character data
NAXIS   =                    0 / No Image --- just extension(s)
EXTEND  =                    T / There are standard extensions
ORIGIN  = 'CDS     '           / File generated at CDS, Strasbourg, France
                                 (tofits, Version 3.4)
             e-mail:    question@simbad.u-strasbg.fr
COMMENT  ARG='-m -1 /ftp/cats/J/ApJ/913/38/./table5.dat'
LONGSTRN= 'OGIP 1.0'           / Long string convention (&/CONTINUE) may be used
DATE    = '2023-10-12'         / Written on 2023-10-12:13:12:10 (GMT)
                             by: www-data@cdsarc.astro.unistra.fr
CDS-CAT = 'J/ApJ/913/38'       / Catalogue designation in CDS nomenclature
COMMENT  Compilation of Cepheids in the MW and MCs (Breuval+, 2021)
COMMENT  Title:  The influence of metallicity on the Leavitt law from
                 geometrical distances of Milky Way and Magellanic Cloud
                 Cepheids.
AUTHOR  = 'Breuval L., Kervella P., Wielgorski P., Gieren W., Graczyk D., Trah&'
CONTINUE  'in B.,&'
CONTINUE  'Pietrzynski G., Arenou F., Javanmardi B., Zgirski B.'
REFERENC= 'Astrophys. J., 913, 38-38 (2021)'
BIBCODE = '2021ApJ…913…38B' / 19-digit SIMBAD/NED/ADS BibCode
COMMENT  ADC_Keywords: Stars, variable; Photometry, UBVRI; Stars, distances;
         Milky Way;
         Abundances, [Fe/H]; Parallaxes, trigonometric; Magellanic Clouds
COMMENT  Keywords: Cepheid distance; Parallax; Metallicity; Magellanic Clouds
```

```
        Milky Way Galaxy
COMMENT  Abstract:
        The Cepheid period-luminosity (PL) relation is the key tool for
        measuring astronomical distances and for establishing the
        extragalactic distance scale. In particular, the local value of the
        Hubble constant (H_0_) strongly depends on Cepheid distance
        measurements. The recent Gaia Data Releases and other parallax
        measurements from the Hubble Space Telescope (HST) already enabled us
        to improve the accuracy of the slope ({alpha}) and intercept ({beta})
        of the PL relation. However, the dependence of this law on metallicity
        is still largely debated. In this paper, we combine three samples of
        Cepheids in the Milky Way (MW), the Large Magellanic Cloud (LMC), and
        the Small Magellanic Cloud (SMC) in order to derive the metallicity
        term (hereafter {gamma}) of the PL relation. The recent publication of
        extremely precise LMC and SMC distances based on late-type detached
        eclipsing binary systems provides a solid anchor for the Magellanic
        Clouds. In the MW, we adopt Cepheid parallaxes from the early third
        Gaia Data Release. We derive the metallicity effect in V, I, J, H,
        K_S_, W_VI_, and W_JK_. In the K_S_ band we report a metallicity
        effect of -0.221+/-0.051mag/dex, the negative sign meaning that more
        metal-rich Cepheids are intrinsically brighter than their more
        metal-poor counterparts of the same pulsation period.
COMMENT  File Summary:
        ----------------------------------------------------------------------
         FileName        Lrecl  Records   Explanations
        ----------------------------------------------------------------------
         ReadMe             80        .    This file
         table3.dat         67      188    Sample of Milky Way Cepheids and
        main parameters
         table4.dat         92      222    Optical and NIR mean apparent
        magnitudes for
                                       the sample of Milky Way Cepheids
         table5.dat        131     1519    Sample of Large Magellanic Cloud
        Cepheids and
                                       their main parameters
         table6.dat        131      300    Sample of Small Magellanic Cloud
        Cepheids and
                                       their main parameters
        ----------------------------------------------------------------------
COMMENT  See also:
        B/vsx  : AAVSO International Variable Star Index VSX (Watson+, 2006-)
        II/246 : 2MASS All-Sky Catalog of Point Sources (Cutri+ 2003)
        II/285 : Photoelectric observations of Cepheids in UBV(RI)c
        (Berdnikov, 2008)
        I/350  : Gaia EDR3 (Gaia Collaboration, 2020)
        J/AcA/49/543  : OGLE LMC & SMC Cepheids VI photometry (Pietrzynski+,
        1999)
        J/AcA/51/221  : OGLE-II. Cepheids in IC 1613 (Udalski+, 2001)
```

```
         J/AJ/128/2239 : JHKs photometry of 92 LMC Cepheids (Persson+, 2004)
         J/ApJ/652/1133   : BVI photometry of NGC 4258 Cepheids (Macri+, 2006)
         J/MNRAS/386/2115 : Type II Cepheid and RR Lyrae variables (Feast+,
         2008)
         J/AcA/58/313  : LMC Cepheids in OGLE and MACHO data (Poleski+, 2008)
         J/ApJS/193/12 : JHK photometry of Northern Galactic Cepheids (Monson+,
         2011)
         J/AJ/142/51   : Galactic Cepheids abundance variations (Luck+, 2011)
         J/A+A/534/A94 : Milky Way Cepheids radial velocities (Storm+, 2011)
         J/A+A/534/A95 : LMC Cepheids radial velocities (Storm+, 2011)
         J/AJ/142/136  : Spectroscopy of Cepheids. l=30-250{deg} (Luck+, 2011)
         J/MNRAS/420/1590 : Abundances of classical Cepheids (Acharova+, 2012)
         J/A+A/554/A132   : Iron line list (FeI and FeII) (Genovali+, 2013)
         J/A+A/566/A37 : Iron abundances for 42 Galactic Cepheids (Genovali+,
         2014)
         J/AcA/65/233  : OGLE Magellanic Clouds anomalous Cepheids (Soszynski+,
         2015)
         J/AJ/149/117  : LMC infrared survey. I. Photometry of Cepheids
         (Macri+, 2015)
         J/A+A/580/A17 : {alpha}-element abundances of Cepheid stars
         (Genovali+, 2015)
         J/ApJS/224/21 : The VMC survey. XIX. Classical Cepheids in SMC
         (Ripepi+, 2016)
         J/ApJ/826/56  : HST/WFC3 obs. of Cepheids in SN Ia host gal. (Riess+,
         2016)
         J/ApJ/832/176 : Classical Cepheids in MCs. I. LMC disk (Inno+, 2016)
         J/ApJ/842/42  : Improved reddenings for 59 Galactic Cepheids (Madore+,
         2017)
         J/MNRAS/472/808 : YJKs light curves of SMC Classical Cepheids
         (Ripepi+, 2017)
         J/AJ/156/171  : Cepheid abundances (Luck, 2018)
         J/A+A/619/A8  : Cepheid PL-metallicity relation (Groenewegen, 2018)
         J/A+A/620/A99 : SMC Cepheids K-band and RV curves (Gieren+, 2018)
         J/A+A/623/A72 : Binarity of HIP stars from Gaia pm anomaly (Kervella+,
         2019)
         J/A+A/625/A14 : Reclassification of Cepheids in the Gaia DR2 (Ripepi+,
         2019)
         J/ApJ/876/85  : HST observations for LMC Cepheids (Riess+, 2019)
         J/ApJ/911/12  : HST opt-NIR obs. of Cepheids in NGC5584 (Javanmardi+,
         2021)
COMMENT  Unused Described file:  table3.dat
COMMENT  Unused Described file:  table4.dat
COMMENT  Unused Described file:  table[56].dat
COMMENT  History:
         From electronic version of the journal
         ================================================================
HISTORY  (End) Prepared by [AAS], Emmanuelle Perret [CDS] 25-Nov-2022
>
```

```
<bound method Header.items of XTENSION= 'TABLE   '           / Ascii Table
Extension
BITPIX  =                    8 / Character data
NAXIS   =                    2 / Simple 2-D matrix
NAXIS1  =                  131 / Number of bytes per record
NAXIS2  =                 1519 / Number of records
PCOUNT  =                    0 / Get rid of random parameters
GCOUNT  =                    1 / Only one group (isn't it obvious?)
TFIELDS =                   18 / Number of data fields (columns)
EQUINOX =                2000. / Equinox of coordinates (J system)
EXTNAME = 'table5.dat'         / Sample of Large Magellanic Cloud Cepheids and
                                 their main parameters
         ======================================================================
TBCOL1  =                    1 / ============== Start column +0
TFORM1  = 'A17     '           / Fortran Format
TTYPE1  = 'Star    '           / Cepheid identifier
TBCOL2  =                   19 / ============== Start column +18
TUNIT2  = 'd       '           / Unit: day
TFORM2  = 'F6.3    '           / Fortran Format
TDISP2  = 'F6.3    '           / Display Format for Binary Tables
TTYPE2  = 'Per     '           / [2.5/48.4] Period
TAMIN2  =                2.500 / Allowed minimal value
TAMAX2  =               48.400 / Allowed maximal value
TBCOL3  =                   26 / ============== Start column +25
TUNIT3  = 'deg     '           / Unit: degree
TFORM3  = 'F7.4    '           / Fortran Format
TDISP3  = 'F7.4    '           / Display Format for Binary Tables
TTYPE3  = 'RAdeg   '           / Right Ascension in decimal degrees (J2000)
TAMIN3  =               0.0000 / Allowed minimal value
TAMAX3  =             360.0000 / Allowed maximal value EXCLUSIVE (never reached)
TBCOL4  =                   34 / ============== Start column +33
TUNIT4  = 'deg     '           / Unit: degree
TFORM4  = 'F8.4    '           / Fortran Format
TDISP4  = 'F8.4    '           / Display Format for Binary Tables
TTYPE4  = 'DEdeg   '           / Declination in decimal degrees (J2000)
TAMIN4  =             -90.0000 / Allowed minimal value
TAMAX4  =              90.0000 / Allowed maximal value
TBCOL5  =                   43 / ============== Start column +42
TUNIT5  = 'kpc     '           / Unit: kiloparsec
TFORM5  = 'F7.4    '           / Fortran Format
TDISP5  = 'F7.4    '           / Display Format for Binary Tables
TTYPE5  = 'Dist    '           / [48.5/63.9] Distance (1)
TAMIN5  =              48.5000 / Allowed minimal value
TAMAX5  =              63.9000 / Allowed maximal value
TBCOL6  =                   51 / ============== Start column +50
TUNIT6  = 'kpc     '           / Unit: kiloparsec
TFORM6  = 'F6.4    '           / Fortran Format
TDISP6  = 'F6.4    '           / Display Format for Binary Tables
```

```
TTYPE6  = 'e_Dist  '           / [0.5/1] Uncertainty in Dist
TAMIN6  =               0.5000 / Allowed minimal value
TAMAX6  =               1.0000 / Allowed maximal value
TBCOL7  =                   58 / ============== Start column +57
TUNIT7  = 'mag     '           / Unit: magnitude
TFORM7  = 'F6.3    '           / Fortran Format
TDISP7  = 'F6.3    '           / Display Format for Binary Tables
TTYPE7  = 'Vmag    '           / [0/19]? Apparent mean V band magnitude (2)
TAMIN7  =                0.000 / Allowed minimal value
TAMAX7  =               19.000 / Allowed maximal value
TBNUL7  = '        '           / NULL (undefined) value
TBCOL8  =                   65 / ============== Start column +64
TUNIT8  = 'mag     '           / Unit: magnitude
TFORM8  = 'F4.2    '           / Fortran Format
TDISP8  = 'F4.2    '           / Display Format for Binary Tables
TTYPE8  = 'e_Vmag  '           / [0/0.02]? Uncertainty in Vmag
TAMIN8  =                 0.00 / Allowed minimal value
TAMAX8  =                 0.02 / Allowed maximal value
TBNUL8  = '        '           / NULL (undefined) value
TBCOL9  =                   70 / ============== Start column +69
TUNIT9  = 'mag     '           / Unit: magnitude
TFORM9  = 'F6.3    '           / Fortran Format
TDISP9  = 'F6.3    '           / Display Format for Binary Tables
TTYPE9  = 'Imag    '           / [12/17.3]? Apparent mean I band magnitude (2)
TAMIN9  =               12.000 / Allowed minimal value
TAMAX9  =               17.300 / Allowed maximal value
TBNUL9  = '        '           / NULL (undefined) value
TBCOL10 =                   77 / ============== Start column +76
TUNIT10 = 'mag     '           / Unit: magnitude
TFORM10 = 'F4.2    '           / Fortran Format
TDISP10 = 'F4.2    '           / Display Format for Binary Tables
TTYPE10 = 'e_Imag  '           / [0.02]? Uncertainty in Imag
TAMIN10 =                 0.02 / Allowed minimal value
TAMAX10 =                 0.02 / Allowed maximal value
TBNUL10 = '        '           / NULL (undefined) value
TBCOL11 =                   82 / ============== Start column +81
TUNIT11 = 'mag     '           / Unit: magnitude
TFORM11 = 'F6.3    '           / Fortran Format
TDISP11 = 'F6.3    '           / Display Format for Binary Tables
TTYPE11 = 'Jmag    '           / [10.75/16.1]? Apparent mean J band magnitude
                                 (2)
TAMIN11 =               10.750 / Allowed minimal value
TAMAX11 =               16.100 / Allowed maximal value
TBNUL11 = '        '           / NULL (undefined) value
TBCOL12 =                   89 / ============== Start column +88
TUNIT12 = 'mag     '           / Unit: magnitude
TFORM12 = 'F5.3    '           / Fortran Format
TDISP12 = 'F5.3    '           / Display Format for Binary Tables
```

```
TTYPE12 = 'e_Jmag  '           / [0.002/0.2]? Uncertainty in Jmag
TAMIN12 =                0.002 / Allowed minimal value
TAMAX12 =                0.200 / Allowed maximal value
TBNUL12 = '        '           / NULL (undefined) value
TBCOL13 =                   95 / ============== Start column +94
TUNIT13 = 'mag     '           / Unit: magnitude
TFORM13 = 'F6.3    '           / Fortran Format
TDISP13 = 'F6.3    '           / Display Format for Binary Tables
TTYPE13 = 'Hmag    '           / [10.42/15.02]? Apparent mean H band magnitude
                                 (2)
TAMIN13 =               10.420 / Allowed minimal value
TAMAX13 =               15.020 / Allowed maximal value
TBNUL13 = '        '           / NULL (undefined) value
TBCOL14 =                  102 / ============== Start column +101
TUNIT14 = 'mag     '           / Unit: magnitude
TFORM14 = 'F5.3    '           / Fortran Format
TDISP14 = 'F5.3    '           / Display Format for Binary Tables
TTYPE14 = 'e_Hmag  '           / [0.01/0.2]? Uncertainty in Hmag
TAMIN14 =                0.010 / Allowed minimal value
TAMAX14 =                0.200 / Allowed maximal value
TBNUL14 = '        '           / NULL (undefined) value
TBCOL15 =                  108 / ============== Start column +107
TUNIT15 = 'mag     '           / Unit: magnitude
TFORM15 = 'F6.3    '           / Fortran Format
TDISP15 = 'F6.3    '           / Display Format for Binary Tables
TTYPE15 = 'Ksmag   '           / [10.32/15.6]? Apparent mean Ks band magnitude
                                 (2)
TAMIN15 =               10.320 / Allowed minimal value
TAMAX15 =               15.600 / Allowed maximal value
TBNUL15 = '        '           / NULL (undefined) value
TBCOL16 =                  115 / ============== Start column +114
TUNIT16 = 'mag     '           / Unit: magnitude
TFORM16 = 'F5.3    '           / Fortran Format
TDISP16 = 'F5.3    '           / Display Format for Binary Tables
TTYPE16 = 'e_Ksmag '           / [0.002/0.2]? Uncertainty in Ksmag
TAMIN16 =                0.002 / Allowed minimal value
TAMAX16 =                0.200 / Allowed maximal value
TBNUL16 = '        '           / NULL (undefined) value
TBCOL17 =                  121 / ============== Start column +120
TUNIT17 = 'mag     '           / Unit: magnitude
TFORM17 = 'F5.3    '           / Fortran Format
TDISP17 = 'F5.3    '           / Display Format for Binary Tables
TTYPE17 = 'E(B-V)  '           / [0.074/0.3] The (B-V) color excess
TAMIN17 =                0.074 / Allowed minimal value
TAMAX17 =                0.300 / Allowed maximal value
TBCOL18 =                  127 / ============== Start column +126
TUNIT18 = 'mag     '           / Unit: magnitude
TFORM18 = 'F5.3    '           / Fortran Format
```

```
TDISP18 = 'F5.3    '           / Display Format for Binary Tables
TTYPE18 = 'e_E(B-V)'           / [0.015/0.017] Uncertainty in E (B-V)
TAMIN18 =                0.015 / Allowed minimal value
TAMAX18 =                0.017 / Allowed maximal value
         ======================================================================
COMMENT  Note (1): Corrected for their position in the LMC by the equations
         provided
         in Section 3.2 or in the SMC by equations provided in Section 3.3.
COMMENT  Note (2): Not corrected for the reddening.
========================================================================>
HV953
0.0
Per: 47.89 Dist: 49.1408 Ks: 10.32
```

table 6 SMC

[64]:
```python
hdus=fits.open("table6.dat.fits")
print(hdus.info())
print(hdus["PRIMARY"].header.items)
print(hdus["table6.dat"].header.items)
#print(hdus["table3.dat"].data.shape)
#hdus.verify("fix")
data=hdus[1].data
print(data[0].field(0))
print(data[0].field(7))
print('Vmag:', data[0].field('Vmag'), 'Imag:', data[0].field('Imag'),'Ks:',␣
 ↪data[0].field('Ksmag'))
hdus.close()
```

```
Filename: table6.dat.fits
No.    Name      Ver    Type      Cards   Dimensions   Format
  0  PRIMARY       1 PrimaryHDU     118   ()
  1  table6.dat    1 TableHDU       153   300R x 18C   [A17, F6.3, F7.4, F8.4,
F7.4, F6.4, F6.3, F4.2, F6.3, F4.2, F6.3, F5.3, F6.3, F5.3, F6.3, F5.3, F5.3,
F5.3]
None
<bound method Header.items of SIMPLE  =                    T / Standard FITS
Format
BITPIX  =                    8 / Character data
NAXIS   =                    0 / No Image --- just extension(s)
EXTEND  =                    T / There are standard extensions
ORIGIN  = 'CDS     '           / File generated at CDS, Strasbourg, France
                                 (tofits, Version 3.4)
             e-mail:    question@simbad.u-strasbg.fr
COMMENT  ARG='-m -1 /ftp/cats/J/ApJ/913/38/./table6.dat'
LONGSTRN= 'OGIP 1.0'           / Long string convention (&/CONTINUE) may be used
DATE    = '2023-10-12'         / Written on 2023-10-12:13:12:14 (GMT)
                             by: www-data@cdsarc.astro.unistra.fr
```

```
CDS-CAT = 'J/ApJ/913/38'       / Catalogue designation in CDS nomenclature
COMMENT  Compilation of Cepheids in the MW and MCs (Breuval+, 2021)
COMMENT  Title:  The influence of metallicity on the Leavitt law from
                 geometrical distances of Milky Way and Magellanic Cloud
                 Cepheids.
AUTHOR  = 'Breuval L., Kervella P., Wielgorski P., Gieren W., Graczyk D., Trah&'
CONTINUE  'in B.,&'
CONTINUE  'Pietrzynski G., Arenou F., Javanmardi B., Zgirski B.'
REFERENC= 'Astrophys. J., 913, 38-38 (2021)'
BIBCODE = '2021ApJ…913…38B' / 19-digit SIMBAD/NED/ADS BibCode
COMMENT  ADC_Keywords: Stars, variable; Photometry, UBVRI; Stars, distances;
         Milky Way;
         Abundances, [Fe/H]; Parallaxes, trigonometric; Magellanic Clouds
COMMENT  Keywords: Cepheid distance; Parallax; Metallicity; Magellanic Clouds
         Milky Way Galaxy
COMMENT  Abstract:
         The Cepheid period-luminosity (PL) relation is the key tool for
         measuring astronomical distances and for establishing the
         extragalactic distance scale. In particular, the local value of the
         Hubble constant (H_0_) strongly depends on Cepheid distance
         measurements. The recent Gaia Data Releases and other parallax
         measurements from the Hubble Space Telescope (HST) already enabled us
         to improve the accuracy of the slope ({alpha}) and intercept ({beta})
         of the PL relation. However, the dependence of this law on metallicity
         is still largely debated. In this paper, we combine three samples of
         Cepheids in the Milky Way (MW), the Large Magellanic Cloud (LMC), and
         the Small Magellanic Cloud (SMC) in order to derive the metallicity
         term (hereafter {gamma}) of the PL relation. The recent publication of
         extremely precise LMC and SMC distances based on late-type detached
         eclipsing binary systems provides a solid anchor for the Magellanic
         Clouds. In the MW, we adopt Cepheid parallaxes from the early third
         Gaia Data Release. We derive the metallicity effect in V, I, J, H,
         K_S_, W_VI_, and W_JK_. In the K_S_ band we report a metallicity
         effect of -0.221+/-0.051mag/dex, the negative sign meaning that more
         metal-rich Cepheids are intrinsically brighter than their more
         metal-poor counterparts of the same pulsation period.
COMMENT  File Summary:
         -----------------------------------------------------------------------
          FileName        Lrecl  Records   Explanations
         -----------------------------------------------------------------------
          ReadMe            80        .    This file
          table3.dat        67      188    Sample of Milky Way Cepheids and
         main parameters
          table4.dat        92      222    Optical and NIR mean apparent
         magnitudes for
                                       the sample of Milky Way Cepheids
          table5.dat       131     1519    Sample of Large Magellanic Cloud
         Cepheids and
```

```
                              their main parameters
 table6.dat        131      300    Sample of Small Magellanic Cloud
Cepheids and
                              their main parameters
--------------------------------------------------------------------------------
COMMENT  See also:
B/vsx  : AAVSO International Variable Star Index VSX (Watson+, 2006-)
II/246 : 2MASS All-Sky Catalog of Point Sources (Cutri+ 2003)
II/285 : Photoelectric observations of Cepheids in UBV(RI)c
(Berdnikov, 2008)
I/350  : Gaia EDR3 (Gaia Collaboration, 2020)
J/AcA/49/543  : OGLE LMC & SMC Cepheids VI photometry (Pietrzynski+,
1999)
J/AcA/51/221  : OGLE-II. Cepheids in IC 1613 (Udalski+, 2001)
J/AJ/128/2239 : JHKs photometry of 92 LMC Cepheids (Persson+, 2004)
J/ApJ/652/1133   : BVI photometry of NGC 4258 Cepheids (Macri+, 2006)
J/MNRAS/386/2115 : Type II Cepheid and RR Lyrae variables (Feast+,
2008)
J/AcA/58/313  : LMC Cepheids in OGLE and MACHO data (Poleski+, 2008)
J/ApJS/193/12 : JHK photometry of Northern Galactic Cepheids (Monson+,
2011)
J/AJ/142/51   : Galactic Cepheids abundance variations (Luck+, 2011)
J/A+A/534/A94 : Milky Way Cepheids radial velocities (Storm+, 2011)
J/A+A/534/A95 : LMC Cepheids radial velocities (Storm+, 2011)
J/AJ/142/136  : Spectroscopy of Cepheids. l=30-250{deg} (Luck+, 2011)
J/MNRAS/420/1590 : Abundances of classical Cepheids (Acharova+, 2012)
J/A+A/554/A132   : Iron line list (FeI and FeII) (Genovali+, 2013)
J/A+A/566/A37 : Iron abundances for 42 Galactic Cepheids (Genovali+,
2014)
J/AcA/65/233  : OGLE Magellanic Clouds anomalous Cepheids (Soszynski+,
2015)
J/AJ/149/117  : LMC infrared survey. I. Photometry of Cepheids
(Macri+, 2015)
J/A+A/580/A17 : {alpha}-element abundances of Cepheid stars
(Genovali+, 2015)
J/ApJS/224/21 : The VMC survey. XIX. Classical Cepheids in SMC
(Ripepi+, 2016)
J/ApJ/826/56  : HST/WFC3 obs. of Cepheids in SN Ia host gal. (Riess+,
2016)
J/ApJ/832/176 : Classical Cepheids in MCs. I. LMC disk (Inno+, 2016)
J/ApJ/842/42  : Improved reddenings for 59 Galactic Cepheids (Madore+,
2017)
J/MNRAS/472/808 : YJKs light curves of SMC Classical Cepheids
(Ripepi+, 2017)
J/AJ/156/171  : Cepheid abundances (Luck, 2018)
J/A+A/619/A8  : Cepheid PL-metallicity relation (Groenewegen, 2018)
J/A+A/620/A99 : SMC Cepheids K-band and RV curves (Gieren+, 2018)
J/A+A/623/A72 : Binarity of HIP stars from Gaia pm anomaly (Kervella+,
```

```
        2019)
        J/A+A/625/A14 : Reclassification of Cepheids in the Gaia DR2 (Ripepi+,
        2019)
        J/ApJ/876/85  : HST observations for LMC Cepheids (Riess+, 2019)
        J/ApJ/911/12  : HST opt-NIR obs. of Cepheids in NGC5584 (Javanmardi+,
        2021)
COMMENT  Unused Described file:  table3.dat
COMMENT  Unused Described file:  table4.dat
COMMENT  Unused Described file:  table[56].dat
COMMENT  History:
        From electronic version of the journal
        ========================================================================
HISTORY  (End) Prepared by [AAS], Emmanuelle Perret [CDS] 25-Nov-2022
>
<bound method Header.items of XTENSION= 'TABLE   '           / Ascii Table
Extension
BITPIX  =                    8 / Character data
NAXIS   =                    2 / Simple 2-D matrix
NAXIS1  =                  131 / Number of bytes per record
NAXIS2  =                  300 / Number of records
PCOUNT  =                    0 / Get rid of random parameters
GCOUNT  =                    1 / Only one group (isn't it obvious?)
TFIELDS =                   18 / Number of data fields (columns)
EQUINOX =                2000. / Equinox of coordinates (J system)
EXTNAME = 'table6.dat'         / Sample of Small Magellanic Cloud Cepheids and
                                 their main parameters
        ========================================================================
TBCOL1  =                    1 / ============== Start column +0
TFORM1  = 'A17     '           / Fortran Format
TTYPE1  = 'Star    '           / Cepheid identifier
TBCOL2  =                   19 / ============== Start column +18
TUNIT2  = 'd       '           / Unit: day
TFORM2  = 'F6.3    '           / Fortran Format
TDISP2  = 'F6.3    '           / Display Format for Binary Tables
TTYPE2  = 'Per     '           / [2.5/48.4] Period
TAMIN2  =                2.500 / Allowed minimal value
TAMAX2  =               48.400 / Allowed maximal value
TBCOL3  =                   26 / ============== Start column +25
TUNIT3  = 'deg     '           / Unit: degree
TFORM3  = 'F7.4    '           / Fortran Format
TDISP3  = 'F7.4    '           / Display Format for Binary Tables
TTYPE3  = 'RAdeg   '           / Right Ascension in decimal degrees (J2000)
TAMIN3  =               0.0000 / Allowed minimal value
TAMAX3  =             360.0000 / Allowed maximal value EXCLUSIVE (never reached)
TBCOL4  =                   34 / ============== Start column +33
TUNIT4  = 'deg     '           / Unit: degree
TFORM4  = 'F8.4    '           / Fortran Format
TDISP4  = 'F8.4    '           / Display Format for Binary Tables
```

```
TTYPE4  = 'DEdeg   '           / Declination in decimal degrees (J2000)
TAMIN4  =             -90.0000 / Allowed minimal value
TAMAX4  =              90.0000 / Allowed maximal value
TBCOL5  =                   43 / ============== Start column +42
TUNIT5  = 'kpc     '           / Unit: kiloparsec
TFORM5  = 'F7.4    '           / Fortran Format
TDISP5  = 'F7.4    '           / Display Format for Binary Tables
TTYPE5  = 'Dist    '           / [48.5/63.9] Distance (1)
TAMIN5  =              48.5000 / Allowed minimal value
TAMAX5  =              63.9000 / Allowed maximal value
TBCOL6  =                   51 / ============== Start column +50
TUNIT6  = 'kpc     '           / Unit: kiloparsec
TFORM6  = 'F6.4    '           / Fortran Format
TDISP6  = 'F6.4    '           / Display Format for Binary Tables
TTYPE6  = 'e_Dist  '           / [0.5/1] Uncertainty in Dist
TAMIN6  =               0.5000 / Allowed minimal value
TAMAX6  =               1.0000 / Allowed maximal value
TBCOL7  =                   58 / ============== Start column +57
TUNIT7  = 'mag     '           / Unit: magnitude
TFORM7  = 'F6.3    '           / Fortran Format
TDISP7  = 'F6.3    '           / Display Format for Binary Tables
TTYPE7  = 'Vmag    '           / [0/19]? Apparent mean V band magnitude (2)
TAMIN7  =                0.000 / Allowed minimal value
TAMAX7  =               19.000 / Allowed maximal value
TBNUL7  = '        '           / NULL (undefined) value
TBCOL8  =                   65 / ============== Start column +64
TUNIT8  = 'mag     '           / Unit: magnitude
TFORM8  = 'F4.2    '           / Fortran Format
TDISP8  = 'F4.2    '           / Display Format for Binary Tables
TTYPE8  = 'e_Vmag  '           / [0/0.02]? Uncertainty in Vmag
TAMIN8  =                 0.00 / Allowed minimal value
TAMAX8  =                 0.02 / Allowed maximal value
TBNUL8  = '        '           / NULL (undefined) value
TBCOL9  =                   70 / ============== Start column +69
TUNIT9  = 'mag     '           / Unit: magnitude
TFORM9  = 'F6.3    '           / Fortran Format
TDISP9  = 'F6.3    '           / Display Format for Binary Tables
TTYPE9  = 'Imag    '           / [12/17.3]? Apparent mean I band magnitude (2)
TAMIN9  =               12.000 / Allowed minimal value
TAMAX9  =               17.300 / Allowed maximal value
TBNUL9  = '        '           / NULL (undefined) value
TBCOL10 =                   77 / ============== Start column +76
TUNIT10 = 'mag     '           / Unit: magnitude
TFORM10 = 'F4.2    '           / Fortran Format
TDISP10 = 'F4.2    '           / Display Format for Binary Tables
TTYPE10 = 'e_Imag  '           / [0.02]? Uncertainty in Imag
TAMIN10 =                 0.02 / Allowed minimal value
TAMAX10 =                 0.02 / Allowed maximal value
```

```
TBNUL10 = '        '           / NULL (undefined) value
TBCOL11 =                   82 / ============== Start column +81
TUNIT11 = 'mag     '           / Unit: magnitude
TFORM11 = 'F6.3    '           / Fortran Format
TDISP11 = 'F6.3    '           / Display Format for Binary Tables
TTYPE11 = 'Jmag    '           / [10.75/16.1]? Apparent mean J band magnitude
                                 (2)
TAMIN11 =               10.750 / Allowed minimal value
TAMAX11 =               16.100 / Allowed maximal value
TBNUL11 = '        '           / NULL (undefined) value
TBCOL12 =                   89 / ============== Start column +88
TUNIT12 = 'mag     '           / Unit: magnitude
TFORM12 = 'F5.3    '           / Fortran Format
TDISP12 = 'F5.3    '           / Display Format for Binary Tables
TTYPE12 = 'e_Jmag  '           / [0.002/0.2]? Uncertainty in Jmag
TAMIN12 =                0.002 / Allowed minimal value
TAMAX12 =                0.200 / Allowed maximal value
TBNUL12 = '        '           / NULL (undefined) value
TBCOL13 =                   95 / ============== Start column +94
TUNIT13 = 'mag     '           / Unit: magnitude
TFORM13 = 'F6.3    '           / Fortran Format
TDISP13 = 'F6.3    '           / Display Format for Binary Tables
TTYPE13 = 'Hmag    '           / [10.42/15.02]? Apparent mean H band magnitude
                                 (2)
TAMIN13 =               10.420 / Allowed minimal value
TAMAX13 =               15.020 / Allowed maximal value
TBNUL13 = '        '           / NULL (undefined) value
TBCOL14 =                  102 / ============== Start column +101
TUNIT14 = 'mag     '           / Unit: magnitude
TFORM14 = 'F5.3    '           / Fortran Format
TDISP14 = 'F5.3    '           / Display Format for Binary Tables
TTYPE14 = 'e_Hmag  '           / [0.01/0.2]? Uncertainty in Hmag
TAMIN14 =                0.010 / Allowed minimal value
TAMAX14 =                0.200 / Allowed maximal value
TBNUL14 = '        '           / NULL (undefined) value
TBCOL15 =                  108 / ============== Start column +107
TUNIT15 = 'mag     '           / Unit: magnitude
TFORM15 = 'F6.3    '           / Fortran Format
TDISP15 = 'F6.3    '           / Display Format for Binary Tables
TTYPE15 = 'Ksmag   '           / [10.32/15.6]? Apparent mean Ks band magnitude
                                 (2)
TAMIN15 =               10.320 / Allowed minimal value
TAMAX15 =               15.600 / Allowed maximal value
TBNUL15 = '        '           / NULL (undefined) value
TBCOL16 =                  115 / ============== Start column +114
TUNIT16 = 'mag     '           / Unit: magnitude
TFORM16 = 'F5.3    '           / Fortran Format
TDISP16 = 'F5.3    '           / Display Format for Binary Tables
```

```
TTYPE16 = 'e_Ksmag '           / [0.002/0.2]? Uncertainty in Ksmag
TAMIN16 =                0.002 / Allowed minimal value
TAMAX16 =                0.200 / Allowed maximal value
TBNUL16 = '        '           / NULL (undefined) value
TBCOL17 =                  121 / ============== Start column +120
TUNIT17 = 'mag     '           / Unit: magnitude
TFORM17 = 'F5.3    '           / Fortran Format
TDISP17 = 'F5.3    '           / Display Format for Binary Tables
TTYPE17 = 'E(B-V)  '           / [0.074/0.3] The (B-V) color excess
TAMIN17 =                0.074 / Allowed minimal value
TAMAX17 =                0.300 / Allowed maximal value
TBCOL18 =                  127 / ============== Start column +126
TUNIT18 = 'mag     '           / Unit: magnitude
TFORM18 = 'F5.3    '           / Fortran Format
TDISP18 = 'F5.3    '           / Display Format for Binary Tables
TTYPE18 = 'e_E(B-V)'           / [0.015/0.017] Uncertainty in E (B-V)
TAMIN18 =                0.015 / Allowed minimal value
TAMAX18 =                0.017 / Allowed maximal value
         ======================================================================
COMMENT  Note (1): Corrected for their position in the LMC by the equations
         provided
         in Section 3.2 or in the SMC by equations provided in Section 3.3.
COMMENT  Note (2): Not corrected for the reddening.
==========================================================================>
OGLE-SMC-CEP-0443
0.02
Vmag: 16.443 Imag: 15.671 Ks: 14.742
```

[ ]: