Of serendipitous discoveries

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TWO FAINT STARS WITH LARGE PROPER MOTION.

In a search for companions of stars with large proper motion two plates of the region of Lalande 1299 were taken on September 15, 1914, and two on September 12, 1917. The plates do not show any companion of Lalande 1299 (μ = 1″.37 in p = 146°.9), but reveal a star which has an even larger motion. This star is located...
The 3\textsuperscript{rd} closest white dwarf

Van Maanen
1917, PASP 29, 258
1920, Cont. Mt. Wilson Obs. 182

\textbf{Ca H/K}

\textbf{d=4.4pc}

\[\text{Fe} \quad \text{Mg} \quad \text{Ca}\]

\[\lambda (\text{Å})\]

\[3300 \quad 3600 \quad 3900 \quad 4200 \quad 4500\]

\emph{Anonymous}. 1, \(\alpha = 0^h 43^m 52^s, \delta = +4^\circ 55'.\) In *Publications of the Astronomical Society of the Pacific*, December 1917, I announced that this star has a proper motion of 3''01 annually; Seares found the photo-visual and photographic magnitudes to be 12.34 and 12.91, respectively. The spectrum is Fo. The absolute parallax of +0''.246 gives for the absolute magnitudes, +14.3 photo-visual and +14.8 photographic. It is, therefore, by far the faintest F-type star known at the present time.
White dwarfs 101

\[ R_{\text{wd}} \approx 0.01 R_\odot \approx R_\oplus \]
\[ M_{\text{wd}} \approx 0.65 M_\odot \]

\[ g \approx 10^6 \text{ ms}^{-2} \]
\[ g = 9.8 \text{ ms}^{-2} \]
White dwarfs are chemically stratified

Pure H or He atmosphere

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External pollution, but where do the metals come from?
1987: G29-38, brown dwarf or dust?

What might be a plausible source of dust grains this close to the remnant of a star that underwent a red giant expansion not quite $10^9$ yr ago? Occasional cometary impacts onto white dwarf stars may explain certain photospheric spectroscopic peculiarities and it has been suggested recently that near-misses of comets and white dwarfs could effectively produce circumstellar gas in orbit around the white dwarf (M. Jura, F. Coroniti and C. Alcock, in preparation). Possible evidence for the unlikely given the rapid depletion due to the Poynting–Robertson effect and the absence of any spectral peculiarities in its photospheric spectrum (J. Greenstein, personal communication) which might be expected as a consequence of the rapid accretion of the orbiting material.

A more attractive possibility is that a warm brown dwarf is in orbit around G29 – 38. The upper mass limit for brown dwarfs
1987: G29-38, brown dwarf or dust?


metal pollution
1987: G29-38, brown dwarf or dust?

5. CONCLUSIONS

In conclusion:

1. We have found that the infrared excess around the white dwarf G29-38 can be explained as an opaque ring of refractory dust with inner and outer radii of 0.14 and \( \sim 1 \, R_\odot \), respectively.

2. We propose that the circumstellar ring, which lies within the Roche radius of the white dwarf, was produced by a tidally disrupted asteroid.

3. Accretion from the dust ring can plausibly explain the abundance of calcium in the atmosphere of G29-38. Either as a bombardment by a series of asteroids or because of one large disruption, the total amount of matter accreted onto the white dwarf may have been \( \sim 4 \times 10^{24} \, \text{g} \), about 1% of the mass of asteroids around \( \xi \) Lep.

Asteroids are scattered by unseen planets towards the white dwarfs
Off-topic: accretion discs in close WD binaries

SDSS1035+0558

Balmer lines


Littlefair et al. 2006, Science 314, 1578
2006: A typical white dwarf(?)

Gänsicke et al. 2006, Science 314, 1908
2006: A typical white dwarf - Not

Gänsicke et al. 2006, Science 314, 1908
2006: A gaseous metallic debris disc


Gänsicke et al. 2006, Science 314, 1908
POLLUTION OF SINGLE WHITE DWARFS BY ACCRETION OF MANY SMALL ASTEROIDS

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ABSTRACT

Extrapolating from the solar system’s asteroid belt, we propose that externally contaminated white dwarfs without an infrared excess may be experiencing continuous accretion of gas-phase material that is ultimately derived from the tidal destruction of multiple small asteroids. If this scenario is correct, then observations of metal-polluted white dwarfs may lead to determination of the bulk elemental compositions of ensembles of extrasolar minor planets.

Key words: planetary systems – white dwarfs
Transient Ca II emission

Indirect imaging of debris discs around white dwarfs

CARBON DEFICIENCY IN EXTERNALLY POLLUTED WHITE DWARFS: EVIDENCE FOR ACCRETION OF ASTEROIDS

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ABSTRACT

Existing determinations show that $n(C)/n(\text{Fe})$ is more than a factor of 10 below solar in the atmospheres of three white dwarfs that appear to be externally polluted. These results are not easily explained if the stars have accreted interstellar matter, and we reinterpret these measurements as evidence that these stars have accreted asteroids with a chondritic composition.

Chemical signature rules out accretion from the interstellar medium

THE CHEMICAL COMPOSITION OF AN EXTRASOLAR MINOR PLANET

B. Zuckerman, 1 D. Koester, 2 C. Melis, 1 Brad M. Hansen, 1 and M. Jura 1

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ABSTRACT

We report the relative abundances of 17 elements in the atmosphere of the white dwarf star GD 362, material that, very probably, was contained previously in a large asteroid or asteroids with composition similar to the Earth-Moon system. The asteroid may have once been part of a larger parent body not unlike one of the terrestrial planets of our solar system.

Debris ⇒ bulk abundances of exo-asteroids

Measuring bulk compositions in the solar system
Measuring bulk compositions in the solar system

Meteor crater, Arizona

Jura & Young 2014, ARE&PS 42, 45
O, Mg, Si, and Fe are the major constituents of the debris (and also make up ~93% of the Earth), variations similar to solar system

Jura & Young, 2014, ARE&PS 42, 1
Detailed abundance studies

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Jura & Young, 2014, ARE&PS 42, 1
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- Refractory lithophiles Ca/Al very similar to solar system bodies

Jura & Young, 2014, ARE&PS 42, 1
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- Carbon-depleted, similar to bulk Earth ⇒ “rocky”
- Refractory lithophiles Ca/Al very similar to solar system bodies
- Strong evidence for differentiation (Fe, S, Cr overabundance)

Jura & Young, 2014, ARE&PS 42, 1
Mesosiderite-like exo-asteroids

Mesosiderite “Vaca Muerta” origin from a ~ 200-400 km differentiated asteroid
(Scott et al. 2001, M&PS 36, 869)
What about water?

Jura & Xu 2010, AJ 140, 1129
Jura & Xu 2012, AJ 143, 6
Cool white dwarfs: planetary archaeology

Koester et al. 2011, A&A 530, A114
~230 cool WDs
Rich variety
Of abundances

Hollands et al. in prep
2015: The first detection of debris transits

Vanderburg et al. 2015, Nature 526, 546
Large occulators

\[ R_{\text{cloud}} \gtrsim 2-4R_{\text{wd}} \]

\[ \sim 3\text{min duration} \Rightarrow \text{Average extinction} \approx 10\% \Rightarrow \frac{dM}{dt} \sim 10^{11} \text{g/s} \]

Large occulters

~3min duration
⇒ $R_{\text{cloud}} \geq 2-4R_{\text{wd}}$

Outburst on 67P/ Churyumov–Gerasimenko observed by ROSETTA

N-body tidal disruption setup

Homogenous, $\rho = 2.6 \, \text{g/cm}^3$

Differentiated, $\rho = 3.5 \, \text{g/cm}^3$

Total disruption within a few days

Stable for $>90$ days, Intermittent mantle disruption

Differentiated, $\rho = 3.5 \text{ g/cm}^3$, eccentricity = 0.0
Differentiated, $\rho = 3.5 \, \text{g/cm}^3$, eccentricity = 0.1

Evolved planetary systems around white dwarfs are as common as around main-sequence stars.
They provide insight into the formation, physical properties, and evolution of exoplanets that is very complementary to main sequence systems.
Mike Jura has been a continuous source of inspiration, and has been always a few steps ahead. He will be dearly missed.