Galactic binaries with eLISA

Gijs Nelemans
Radboud University Nijmegen
Outline

- Galactic binaries
- Verification binaries
  - The story of HM Cnc
- Expected populations
  - Population synthesis
  - Astrophysical relevance
  - Comparison with observations
- What will happen in the next 10-15 years?
  - Variability surveys
  - GAIA
- Electro-magnetic counterparts
- Conclusions
Galactic binaries: types (you have seen this before...)

- Components compact objects
  - White dwarf
  - Neutron star
  - Black hole
- Detached
  - Double WD, WD+NS, NS+NS
- Interacting (bright!): two types
  - AM CVn stars (WD accretor)
  - Ultra-compact X-ray binaries (NS accretor)
Verification binaries

Galactic binaries
- Verification (talk Kilic)
- Simulated pop.

Littenberg, Petiteau, Yellow Book
RX J0806 = HM Cancri: period really 5.4 min!

- V = 21 mag, integration time < 1 min (resolve 5.4 min)
- Keck spectroscopy
- 3 years in row bad weather!
- Finally done
- Clearly see doppler modulation lines
- Period confirmed
- Distance large (h ↓)

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How to get simulate: population synthesis

▪ Recipes for stellar and binary evolution (rapid)
  ▪ Single stars: M, R, L, X, Mc, stellar wind(t) + remnant (supernova)
  ▪ (tides), Mass transfer (stability, common envelope...)

Portegies Zwart & Verbunt, 1996
Nelemans et al. 2001
Toonen et al., submitted

▪ Model for initial distributions
  ▪ M1 (IMF)
  ▪ m/M
  ▪ P or a

▪ “Normalisation”
  (e.g. model for the star formation history)
Expected population

- LISA: ~few $10^4$
- eLISA: ~3000
- Problem: nr AM CVn too large (cf obs)
- Different scenarios
  - Cut number
  - Select subclass
  - Different space distribution
- eLISA will tell

Nissanke, Vallisneri et al. 2012
Galactic binaries: astrophysical relevance

- Probes binary evolution
  - Common envelope

- Type Ia Supernovae

- H deficient accretion (and explosions)

- Binary interactions

- Galactic populations/structure
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He nova V445 Pup, Woudt+2010
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- Galactic populations/structure
  - SDSS J0651 12m double WD! Brown et al. 2011
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- Galactic populations/structure
  - Tracers starformation
Stability of mass transfer: danger of explosion
Mass transfer stability

- NS: what happens to super-Eddington mass transfer?
  King, Ritter
- WD: what happens in direct impact case? Tidal coupling?
- Very important for “branching ratios”
- Details of structure donor important

Marsh, Nelemans, Steeghs, 2004
Deloye, Bildsten
H deficient accretion

- **NS:** peculiar X-ray bursts
  - e.g. Cumming, in tZand, Kuulkers

- **WD:**
  - Helium novae
  - When mass transfer rate drops: envelope mass increases → explosion
  - Special type of supernovae
  - Weird SN are found (PTF etc)

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V445 Pup, Woudt+2010

Kasliwal et al 2010

Bildsten et al. 2007
Galactic binaries: Galactic structure

- Distribution sources in Galaxy and distance/sky position error

Petiteau, Littenberg
Galactic binaries: Galactic structure

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Petiteau, Littenberg
More and more double WD discovered

- e.g. Marsh 2011, Kilic et al., Brown et al.

More and more observed detached double WD that will merge within a Hubble time

- Toonen et al., submitted
What will happen in next 15 years?

- ALMA (now)
  - Large mm array (ESO+US)
- JWST 2018 (?)
- E-ELT 2022, TMT 2020?
  - 38m telescope
- SKA 2018+
  - Array radio telescopes
Galactic binaries LISA & ELT

LISA binary magnitudes (faint) in optical (V, I) and NIR (K)

ELT Micado, limiting magnitude 29 in I and K
Transient surveys

- **PTF**
  - Many strange transients
  - Several AM CVns found
  - New strategy: short cadence

- **Pan-STARRS**
  - Phase 1 now

- **LSST 2022**
  - Ultimate transient machine
GAIA

ESA mission, launch 2013
Astrometry, photometry
and radial velocities
of ~1 billion stars...

Map structure Galaxy

Many double WD expected
(but needs to be properly modelled)

Marsh & Nelemans in prep
Galactic populations/structure: GAIA
Complementary EM (optical) observations

- Galactic binaries (GAIA!)
- Sky position
- Additional parameters
  - Masses/periods
  - Inclination, distance
  - Period derivative

First investigations of use of joint data

- Not that many strong correlations
- Amplitude-inclination (but only for “face on” systems!)
- Use of other EM data not clear
- Dependence on sky position makes complicated (work in progress)

Shah et al. submitted
Conclusions

‣ Verification binaries
  ‣ Several known, new ones are still found

‣ GW data will be spectacular

‣ Relevance
  ‣ Common envelope, SNIa, H deficient accretion, binary interactions, Galactic structure

‣ But, what will happen in next 15 years?
  ‣ Transient surveys, GAIA, E-ELT, SKA...

‣ Need to determine use of joint EM + GW data