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J/A+A/580/A131 Circumstellar-interacting supernovae (Taddia+, 2015)

Metallicity at the explosion sites of interacting transients.
Taddia F., Sollerman J., Fremling C., Pastorello A., Leloudas G., Fransson C., Nyholm A., Stritzinger M.D., Ergon M., Roy R., Migotto K.
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Abstract:
Some circumstellar-interacting (CSI) supernovae (SNe) are produced by the explosions of massive stars that have lost mass shortly before the SN explosion. There is evidence that the precursors of some SNe IIn were luminous blue variable (LBV) stars. For a small number of CSI SNe, outbursts have been observed before the SN explosion. Eruptive events of massive stars are named SN impostors (SN IMs) and whether they herald a forthcoming SN or not is still unclear. The large variety of observational properties of CSI SNe suggests the existence of other progenitors, such as red supergiant (RSG) stars with superwinds. Furthermore, the role of metallicity in the mass loss of CSI SN progenitors is still largely unexplored. Our goal is to gain insight into the nature of the progenitor stars of CSI SNe by studying their environments, in particular the metallicity at their locations. We obtain metallicity measurements at the location of 60 transients (including SNe IIn, SNe Ibn, and SN IMs) via emission-line diagnostic on optical spectra obtained at the Nordic Optical Telescope and through public archives. Metallicity values from the literature complement our sample. We compare the metallicity distributions among the different CSI SN subtypes, and to those of other core-collapse SN types. We also search for possible correlations between metallicity and CSI SN observational properties. We find that SN IMs tend to occur in environments with lower metallicity than those of SNe IIn. Among SNe IIn, SN IIn-L(1998S-like) SNe show higher metallicities, similar to those of SNe IIL/P, whereas long-lasting SNe IIn (1988Z-like) show lower metallicities, similar to those of SN IMs. The metallicity distribution of SNe IIn can be reproduced by combining the metallicity distributions of SN IMs (which may be produced by major outbursts of massive stars like LBVs) and SNe IIP (produced by RSGs). The same applies to the distributions of the normalized cumulative rank (NCR) values, which quantifies the SN association to HII regions. For SNe IIn, we find larger mass-loss rates and higher CSM velocities at higher metallicities. The luminosity increment in the optical bands during SN IM outbursts tend to be larger at higher metallicity, whereas the SN IM quiescent optical luminosities tend to be lower. The difference in metallicity between SNe IIn and SN IMs indicates that LBVs are only one of the progenitor channels for SNe IIn, with 1988Z-like and 1998S-like SNe possibly arising from LBVs and RSGs, respectively. Finally, even though line-driven winds likely do not primarily drive the late mass-loss of CSI SN progenitors, metallicity has some impact on the observational properties of these transients.

Description:
In Table 1 we report the list of 60 transients included in our sample. Thirty-five of them are SNe IIn, six are SNe Ibn, one is a SN Ia-CSM, 18 are SN IMs (if we also count SN 2009ip in the SN IMs, then we have 19 of these transients).

With the NOT, long-slit spectra were obtained for the host galaxies of 13 SNe IIn, five SNe Ibn, one SN Ia-CSM, and 16 SN IMs (the derived metallicity for SN 2007sv was published in Tartaglia et al. 2015MNRAS.447..117T). The host galaxies observed at the NOT are marked with the letter "o" in the third column of Table 1. With the NOT, we also obtained broad-band R and narrow-band Hα images for the SNe IIn (except for SN 1995G) and Ibn. We complemented our observed sample with host galaxies whose metallicities (at the center of the galaxy or at the SN position) were already available in the literature (marked with the letter "l" in the third column of Table 1) or whose spectra were available in public archives (marked with the letter "a" in the third column of Table 1).

File Summary:

FileName	Lrecl	Records	Explanations
ReadMe	80	.	This file
table1.dat	160	60	Sample and basic data of 63 (38 SNe IIn, 6 SNe Ibn, 1 SN Ia-CSM, 18 SN IMs) CSI SN host galaxies
table2.dat	77	35	Log of the photometric and spectroscopic observations at the Nordic Optical Telescope with ALFOSC
table3.dat	33	141	Deprojected and normalized distance from the host center and line ratios for the HII regions

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                                    with observed spectrum
table5.dat        156       42   Apparent (u/U,B,V,R/r/unf.,I/i) peak magnitudes,
                                    galactic and host extinction for the SNe IIn,
                                    Ibn, and Ia-CSM of our sample
table6.dat         61       42   Absolute (U/u,B,V,R/r/unf.,I/i) peak magnitudes
                                    for the SNe IIn, Ibn, and Ia-CSM of our sample
table7.dat         86       29   Wind velocity and mass-loss rate for a
                                    subsample of CSI SNe (IIn, Ibn, Ia-CSM).
refs.dat           70       56   References
```

See also:
B/sn : Asiago Supernova Catalogue (Barbon et al., 1999-)

Byte-by-byte Description of file: table1.dat

```
   Bytes Format Units   Label     Explanations

   1-  8  A8     ---     SN        SN name
  10- 19  A10    ---     Type      SN type
  26- 28  A3     ---     Source    [ola/ ] Data source (1)
  30- 56  A27    ---     Host      Host galaxy
  58- 65  F8.6   ---     z         Redshift
  67- 68  I2     h       RAh       SN right ascension (J2000)
  70- 71  I2     min     RAm       SN right ascension (J2000)
  73- 77  F5.2   s       RAs       SN right ascension (J2000)
      79  A1     ---     DE-       SN declination sign (J2000)
  80- 81  I2     deg     DEd       SN declination (J2000)
  83- 84  I2     arcmin  DEm       SN declination (J2000)
  86- 89  F4.1   arcsec  DEs       SN declination (J2000)
  91- 92  I2     h       RAHh      Host galaxy right ascension (J2000)
  94- 95  I2     min     RAHm      Host galaxy right ascension (J2000)
  97-101  F5.2   s       RAHs      Host galaxy right ascension (J2000)
     103  A1     ---     DEH-      Host galaxy declination sign (J2000)
 104-105  I2     deg     DEHd      Host galaxy declination (J2000)
 107-108  I2     arcmin  DEHm      Host galaxy declination (J2000)
 110-113  F4.1   arcsec  DEHs      Host galaxy declination (J2000)
 115-121  F7.4   arcmin  2a        ?=- Major axis
 123-129  F7.4   arcmin  2b        ?=- Minor axis
 131-134  F4.1   ---     ttype     ?=- t-type (2)
     135  A1     ---     l_ttype   [h] h: from Hyperleda
 137-139  I3     deg     PA        ?=- Position angle
 141-147  A7     ---     r2a       Reference for a and b axis (3)
 149-155  A7     ---     rPA       Reference for PA (3)
 157-160  F4.2   ---     rSN/R25   ?=- Radius ratio
```

Note (1): Data sources as follows:
    o = observed
    l = literature
    a = archive
Note (2): The t-type is obtained from the ASC.

Note (3): References as follows:
    NED = B band (de Vaucouleurs et al., 1991, Cat. VII/155/)
    NED(B) = B band (Palomar survey)
    NED(R) = r band (SDSS)
    NED(IR) = K band (2MASS)
    NED(Be) = B band (ESO survey)
    HYP = Hyperleda
    H97 = Hagen et al., 1997A&A...324L..29H
    ASI = Asiago Supernova Catalogue,
        https://heasarc.gsfc.nasa.gov/W3Browse/all/asiagosn.html
    NED = From NED
    SIM(IR) = From Simbad

Byte-by-byte Description of file: table2.dat

```
   Bytes Format Units   Label     Explanations

   1-  7  A7     ---     SN        SN name
   9- 18  A10    ---     Type      SN type
  25- 38  A14    ---     Galaxy    Galaxy name
      41  A1     ---     Phot1     Photometry filter
  43- 48  A6     ---     Int1      Integration time for Phot1 filter (s)
  50- 56  A7     ---     Phot2     Photometry filter
  58- 62  A5     ---     Int2      Integration time for Phot2 filter (s)
  64- 77  A14    ---     IntSp     Spectroscopy integration time (s) (1)
```

Note (1): Spectroscopic observations were performed with Slit 1.0 +Grism #4.
  We could not image the host galaxies of the SN IMs because during the
  observational campaign of April 2014 several nights were lost due to bad
  weather, and we decided to spend the remaining nights doing spectroscopy.

Byte-by-byte Description of file: table3.dat

Bytes	Format	Units	Label	Explanations
1- 8	A8	---	SN	SN name
11- 15	F5.3	---	r/R25	? Deprojected and normalized distance from the host center
16- 17	A2	---	n_r/R25	[** SN] Note on r/R25 (1)
19	A1	---	l_log(FNII/FHa)	Upper limit flag on log(FNII/FHa)
20- 25	F6.3	[-]	log(FNII/FHa)	Line ratio F([NII]6584)/F(Hα)
27	A1	---	l_log(FOIII/FHb)	Upper limit flag on log(FOIII/FHb)
28- 33	F6.3	[-]	log(FOIII/FHb)	Line ratio F([OIII]5007)/F(Hβ)

Note (1): Notes as follows:
** = Excluded from the metallicity analysis after spectral classification with the BPT diagram.
SN = No Deprojected and normalized distance

Byte-by-byte Description of file: table5.dat

Bytes	Format	Units	Label	Explanations
1- 8	A8	---	SN	SN name
10- 19	A10	---	Type	SN type
25	A1	---	l_Umax	Limit flag on Umax
26- 32	F7.4	mag	Umax	?=- Apparent U peak magnitude
34- 37	F4.2	mag	e_Umax	? rms uncertainty on Umax
40	A1	---	n_Umax	[u] u: u magnitude
43	A1	---	l_Bmax	Limit flag on Bmax
44- 50	F7.4	mag	Bmax	?=- Apparent B peak magnitude
52- 55	F4.2	mag	e_Bmax	? rms uncertainty on Bmax
59	A1	---	l_Vmax	Limit flag on Vmax
60- 66	F7.4	mag	Vmax	?=- Apparent V peak magnitude
68- 71	F4.2	mag	e_Vmax	? rms uncertainty on Vmax
74	A1	---	l_Rmax	Limit flag on Rmax
75- 79	F5.2	mag	Rmax	?=- Apparent R peak magnitude
81- 84	F4.2	mag	e_Rmax	? rms uncertainty on Rmax
87	A1	---	n_Rmax	[ur] r: r magnitude; u: unf magnitude
91	A1	---	l_Imax	Limit flag on Imax
92- 97	F6.3	mag	Imax	?=- Apparent I peak magnitude
99-102	F4.2	mag	e_Imax	? rms uncertainty on Imax
105	A1	---	n_Imax	[i] i: imax magnitude
108-112	F5.3	mag	AV(MW)	Galactic extinction
116-120	F5.3	mag	AV(h)	?=- Host extinction
124-156	A33	---	Ref	References (1)

Note (1): Reference number into parenthesis in refs.dat file.

Byte-by-byte Description of file: table6.dat

Bytes	Format	Units	Label	Explanations
1- 8	A8	---	SN	SN name
10- 19	A10	---	Type	SN type
21	A1	---	l_U/uMax	Limit flag on U/uMax
22- 27	F6.2	mag	U/uMax	?=- Absolute U or u peak magnitude
29	A1	---	l_BMax	Limit flag on BMax
30- 35	F6.2	mag	BMax	?=- Absolute B peak magnitude
37	A1	---	l_VMax	Limit flag on VMax
38- 43	F6.2	mag	VMax	?=- Absolute V peak magnitude
46	A1	---	l_R/r/unfMax	Limit flag on R/r/unfMax
47- 53	F7.3	mag	R/r/unfMax	? Absolute R, r or unf peak magnitude
55	A1	---	l_I/iMax	Limit flag on I/iMax
56- 61	F6.2	mag	I/iMax	?=- Absolute I or i peak magnitude

Byte-by-byte Description of file: table7.dat

Bytes	Format	Units	Label	Explanations
1- 8	A8	---	SN	SN name
10- 19	A10	---	Type	SN type
25	A1	---	l_Vw	Limit flag on Vw
26- 29	I4	km/s	Vw	Wind velocity
30	A1	---	---	[-]

```
 31- 34  I4    km/s       Vwu       ? Upper value of Vw when interval
 37- 40  I4    km/s       e_Vw      ? rms uncertainty on Vw
     42  A1    ---        l_dM/dt   Limit flag on dM/dt
 43- 48  F6.4  Msun/yr    dM/dt     ?=- Mass-loss rate
     49  A1    ---        ---       [-]
 50- 55  F6.4  Msun/yr    dM/dtu    ? Upper value of dM/dt when interval
 57- 62  F6.4  Msun/yr    e_dM/dt   ? rms uncertainty on dM/dt
 65- 86  A22   ---        Ref       References and notes (1)
```

Note (1): * for SN 1998S: Fassia et al. (2000MNRAS.318.1093F) report a
mass-loss rate of 2x10^{-5}M_⊙/yr for the outer CSM and 3x10^{-3}M_⊙/yr
for the inner CSM. The value reported by Anupama et al. (2001A&A...367..506A)
is in the middle of this range.
Reference number into parenthesis in refs.dat file.

Byte-by-byte Description of file: refs.dat

```
  Bytes Format Units   Label     Explanations

  1-  2  I2     ---     Ref       Reference number
  4- 22  A19    ---     BibCode   BibCode
 24- 41  A18    ---     Aut       Author's name
 43- 70  A28    ---     Com       Comments
```

History:
From electronic version of the journal

(End) Patricia Vannier [CDS] 03-Nov-2015