

## Emma Beasor



### Title

The impact of realistic red supergiant mass-loss on stellar evolution: consequences for producing stripped stars via winds

### Abstract

The mass loss rates of red supergiants (RSGs) govern their evolution towards supernova (SN) and dictate the appearance of the resulting explosion. Particularly important in how stars appear in the run-up to core-collapse, and in how the explosion will appear, is the amount of mass lost through stellar winds in the RSG phase that immediately precedes SN. Specifically, there have been many recent claims in the literature that stars with masses  $>17M_{\text{sun}}$  must experience an extended period of enhanced mass-loss before SN in which the envelope is entirely lost. To study how mass-loss rates change with evolution, we focus on measuring the mass-loss rates of RSGs in a sample of clusters in the local Universe. The results indicate that there is little justification for substantially increasing the mass loss rates during the RSG phase. In fact, I have shown that for the more massive RSG the mass-loss rates used in evolutionary simulations must be \*decreased\* by up to a factor of 20. Implementing this new mass-loss rate equation into stellar models shows stars  $< 30M_{\text{sun}}$  cannot have their envelopes stripped through quiescent winds prior to core-collapse. I will also discuss the potential for extreme mass-loss rate phases that have been proposed to take place over a short amount of time, but with the potential to peel away many Solar masses of material. Ultimately, I will discuss prospects for the single star evolutionary pathway for the formation of Type Ibc SNe.

# Emma R. Beasor

✉ embeasor@gmail.com  
✉ emma.beasor@noirlab.edu

## RESEARCH POSITIONS

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**NASA Hubble Postdoctoral Fellow**  
*NOIRLab*

**September 2019 - present**  
*Arizona, USA*

## EDUCATION

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**Astrophysics PhD - Thesis title: The Progenitors of Type IIP Supernovae**  
*Liverpool John Moores University*

**June 2019**  
*Liverpool, UK*

**Astrophysics MPhys**  
*University of Liverpool/Liverpool John Moores University*

**July 2015**  
*Liverpool, UK*

## ATTENDED CONFERENCES AND TALKS

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**Collaboration meeting**  
*Munich, Germany*

**October 2015**  
*Talk*

**Bridging the gap: from massive stars to supernovae**  
*Chicheley Hall, UK*

**June 2016**  
*Contributed talk*

**The lives and death throes of massive stars**  
*Auckland, NZ*

**November 2016**  
*Contributed talk - prize for best student talk*

**UK National Astronomy Meeting**  
*Hull, UK*

**July 2017**  
*Contributed talk*

**The Progenitor-Supernova-Remnant Connection**  
*Ringberg, Germany*

**July 2017**  
*Contributed talk*

**University of Arizona weekly group meeting**  
*Tucson, AZ*

**September 2017**  
*Talk*

**University of Sheffield weekly colloquium**  
*Sheffield, UK*

**October 2018**  
*Invited seminar*

**NHFP Hubble Symposium**  
*Washington DC, USA*

**October 2019**  
*Invited talk*

**NASA Ames weekly colloquium**  
*Moffett Field, CA*

**February 2020**  
*Invited seminar*

**University of Leicester weekly seminar**  
*Remote*

**May 2020**  
*Invited seminar*

**Trinity College Dublin weekly seminar**  
*Remote*

**July 2020**  
*Invited seminar*

**SOFIA Science Center**  
*Remote*

**July 2020**  
*Invited teletalk*

**NSF's OIR Lab/Steward Observatory weekly colloquium**  
*Tucson, AZ*

**September 2020**  
*Invited seminar*

**NHFP Hubble Symposium**  
*Remote*

**September 2020**  
*Invited talk*

**Florida State University weekly seminar**

**November 2020**

<i>Remote</i>	<i>Invited seminar</i>
<b>UCSBs stars group meeting</b>	<b>January 2021</b>
<i>Remote</i>	<i>Invited talk</i>
<b>Massive stars near and far - preview meeting</b>	<b>May 2021</b>
<i>Virtual</i>	<i>Invited talk</i>
<b>GAPS 2021 - unsolved problems in red Giants And suPergiants</b>	<b>June 2021</b>
<i>Virtual</i>	<i>Invited talk</i>
<b>EAS Symposium S16 - Massive stars</b>	<b>June 2021</b>
<i>Remote</i>	<i>Invited review talk</i>
<b>Rochester Institute of Technology</b>	<b>September 2021</b>
<i>Remote</i>	<i>Invited seminar</i>
<b>NHFP Hubble Symposium</b>	<b>October 2021</b>
<i>Remote</i>	<i>Invited talk</i>
<b>Carnegie Observatories</b>	<b>November 2021</b>
<i>Remote</i>	<i>Invited seminar</i>
<b>Massive stars near and far</b>	<b>2022</b>
<i>Ballyconnel, Ireland</i>	<i>Invited talk</i>

## AWARDED GRANTS

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Hubble Fellowship Research Award HST-HF2-51428	\$426,036
RAS travel grant	£1000
IAU Travel grant	400 NZD
LJMU PGR travel fund	£300

## ACCEPTED OBSERVING PROPOSALS

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As PI:.....	
ESO Period 103	10 hours, Very Large Telescope, X-SHOOTER
HST Cycle 29	AR proposal, \$TBD, est. \$100,000
As Co-I.....	
SOFIA Cycle 5	7.5 hours, SOFIA-FORCAST
PI: Nathan Smith	

## OBSERVING EXPERIENCE

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<b>Very Large Telescope (2.5 nights, KMOS)</b>	<b>April 2016</b>
<i>Program ID: 0096.B-0078 - A Stellar View of the Mass-Metallicity Relation</i>	

## RESEARCH SKILLS

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- Using radiative transfer codes (e.g. DUSTY) to model stellar winds
- Spectral fitting
- Modelling spectral energy distributions
- Stellar population synthesis, stellar evolution modelling (using e.g. MESA)
- IDL (fluent), Python (basic), L<sup>A</sup>T<sub>E</sub>X

## TRAINING

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<b>STFC Introductory Summer School</b> <i>Atomic Processes and Spectral Modelling in Astrophysics</i>	<b>August 2015</b> <i>Queens University Belfast</i>
<b>MIAPP</b> <i>The Chemical Evolution of Galaxies</i>	<b>August 2016</b> <i>Garching, Germany</i>
<b>ICIC Data Analysis Workshop</b>	<b>September 2016</b> <i>Imperial College London</i>
<b>Lorentz Centre Workshop</b> <i>Weighing stars from birth to death: how to determine stellar masses?</i>	<b>November 2018</b> <i>Leiden, The Netherlands</i>
<b>MESA Summer School</b>	<b>August 2021</b> <i>Virtual</i>

## TEACHING EXPERIENCE

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<b>Demonstrating in undergraduate problem classes</b>	<b>2015-2018</b>
<b>Demonstrating in undergraduate labs</b>	<b>2016-2018</b>
<b>Co-supervision of Masters students, one of which resulted in publication</b>	<b>2017-2018</b>
<b>Co-supervision of PhD student Sarah McDonald (LJMU)</b>	<b>2020-present</b>

## OUTREACH

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- Running and assisting with educational sessions for primary school children (e.g. 'The scale of the Solar system' workshop)
- Giving physics demonstrations to high school students and their parents
- Assisting at public outreach events within Liverpool (e.g. at the 'Light Night' arts festival)
- Representing Kitt Peak National Observatory at the Tohono O'odham Nation annual rodeo
- Organiser of NOIRLab's Diversity & Inclusion Journal Club series. Monthly discussions of papers on DEI issues in astronomy and academia.
- Authored blog post for NASA.gov website (general audience)

## MEDIA EXPERIENCE

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- Interview on BBC Radio Merseyside
- Featured on '365 Days of Astronomy' podcast
- Interview on BBC Radio 4's 'Today' programme, discussing the Hubble Space Telescope

## SERVICE

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<b>Referee for MNRAS</b>	<b>2019-present</b>
<b>Referee for Science</b>	<b>2021-present</b>
<b>Organiser of NSF's OIR Lab weekly lunch talks (FLASH)</b>	<b>2019-present</b>
<b>Reviewer/panelist for NSF grant proposals (binary/massive stars panel)</b>	<b>2020</b>
<b>Reviewer for FINESST</b>	<b>2020 - 2021</b>
<b>Hubble off-site panel member - Cycles 28 &amp; 29</b>	<b>2020 - 2022</b>
<b>NASA ADAP 20 panelist</b>	<b>2020</b>
<b>NASA ATP 2021 panelist</b>	<b>September 2021</b>

## REFEREES

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**Dr. Ben Davies (Liverpool JMU)**

*b.davies@ljmu.ac.uk*

**Prof. Nathan Smith (University of Arizona)**

*nathans@as.arizona.edu*

**Dr. Selma de Mink (Max Planck Institute for Astrophysics)**

*sedemink@mpa-garching.mpg.de*

## PUBLICATIONS

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### Refereed.....

15. McDonald, S., Davies, B., **Beasor, E. R.**, , "Red Supergiants in M31: The Humphreys-Davidson Limit at high metallicity", in press, arXiv:2111.13716
14. **Beasor, E. R.**, Davies, B., Smith, N., "Implementing realistic red supergiant mass-loss rates in MESA", 2021, ApJ, 922, 55B
13. **Beasor, E. R.**, Davies, B., Smith, N., Gehrz, R., Figer, D. F., "The Age of Westerlund 1 Revisited", 2021, ApJ, 912, 16
12. Davies, B., **Beasor, E. R.**, "'On the red supergiant problem': a rebuttal, and a consensus on the upper mass cut-off for II-P progenitors", 2020, MNRAS, 496 L142
11. Eldridge, J. J., **Beasor, E. R.**, Britavskiy, N., "On ageing star clusters using red supergiants independent of the fraction of interacting binary stars ", 2020, MNRAS, 495, L102
10. **Beasor, E. R.**, Davies, B., Smith, N., van Loon., J, Gehrz, R., Figer, D. F, "A new mass-loss rate prescription for red supergiants", 2020, 493, 468
9. Davies, B., **Beasor, E. R.**, "The Red Supergiant Problem: the upper luminosity boundary ", 2020, MNRAS, 493, 468
8. **Beasor, E. R.**, Davies, B., Smith, N., Bastian, N., "Disprepancies in the ages of young star clusters; evidence for mergers? ", 2019, MNRAS, 486 266
7. Davies, B., **Beasor, E. R.**, "The distances to star clusters hosting Red Supergiants:  $\chi$  Per, NGC 7419 and Westerlund 1 ", 2019, MNRAS, 486 L10
6. **Beasor, E. R.**, Davies, B., Cabrera-Ziri, I., Hurst, G., "A critical re-evaluation of the Thorne- Żytkow object candidate HV 2112 ", 2018, MNRAS, 479 310
5. Davies, B., Crowther, P., **Beasor, E. R.**, "The luminosities of cool supergiants in the Magellanic Clouds, and the Humphreys-Davidson limit revisited", 2018, MNRAS, 478 3138
4. **Beasor, E. R.**, Davies, B., "The evolution of red supergiant mass-loss rates", 2018, MNRAS, 475 55B
3. Davies, B., **Beasor, E. R.**, "The initial masses of the red supergiant progenitors to Type II supernovae", 2018, MNRAS, 474 2116
2. Davies, B., Kudritzki, R-P., Lardo, C., Bergemann, M., **Beasor, E. R.**, Plez, B., Evans, C., Bastian, N., Patrick, L. R., "Red Supergiants as Cosmic Abundance Probes: Massive Star Clusters in M83 and the Mass-Metallicity Relation of Nearby Galaxies", 2017, ApJ, 847 112
1. **Beasor, E. R.**, Davies, B., "The evolution of red supergiants to supernova in NGC 2100", 2016, MNRAS, 463 1269

### In prep/submitted.....

2. **Beasor, E. R.**, Smith, N., "The extreme scarcity of dust-enshrouded red supergiants: consequences for producing stripped stars via winds", submitted to ApJ (available on request)
1. Jencson, J. E. et al. (incl. **Beasor, E. R.**, ) "An Exceptional Dimming Event for a Massive, Cool Supergiant in M51", submitted to ApJ, arxiv:2110.11376

Conference proceedings.....

1. **Beasor, E. R.,** Davies, B., *"The evolution of red supergiants to supernovae"*, 2016, IAUS 329, "The Lives and Death Throes of Massive Stars"

Other.....

2. **Beasor, E. R.,** *"The Age of Westerlund 1 Revisited"*, 2021, SOFIA Spotlight (Scientific audience),  
URL: <https://www.sofia.usra.edu/multimedia/science-results-archive/age-westerlund-1-revisited>
1. **Beasor, E. R.,** *"The Age of Westerlund 1 Revisited"*, 2021, NASA Blog (General audience),  
URL: <https://blogs.nasa.gov/sofia/2021/08/25/the-age-of-westerlund-1-revisited/>