Dust production in galaxies at z > 6

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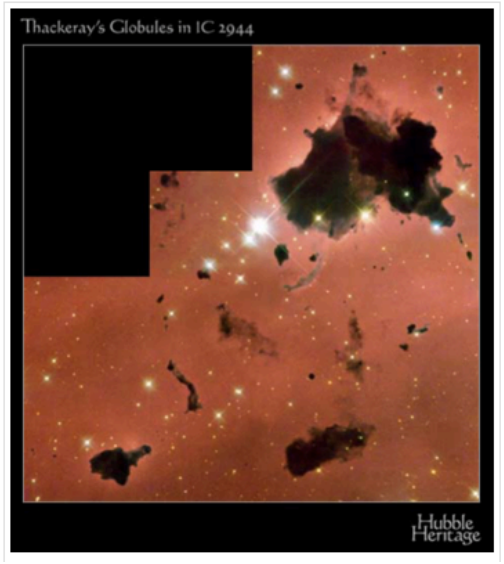
This presentation has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet]

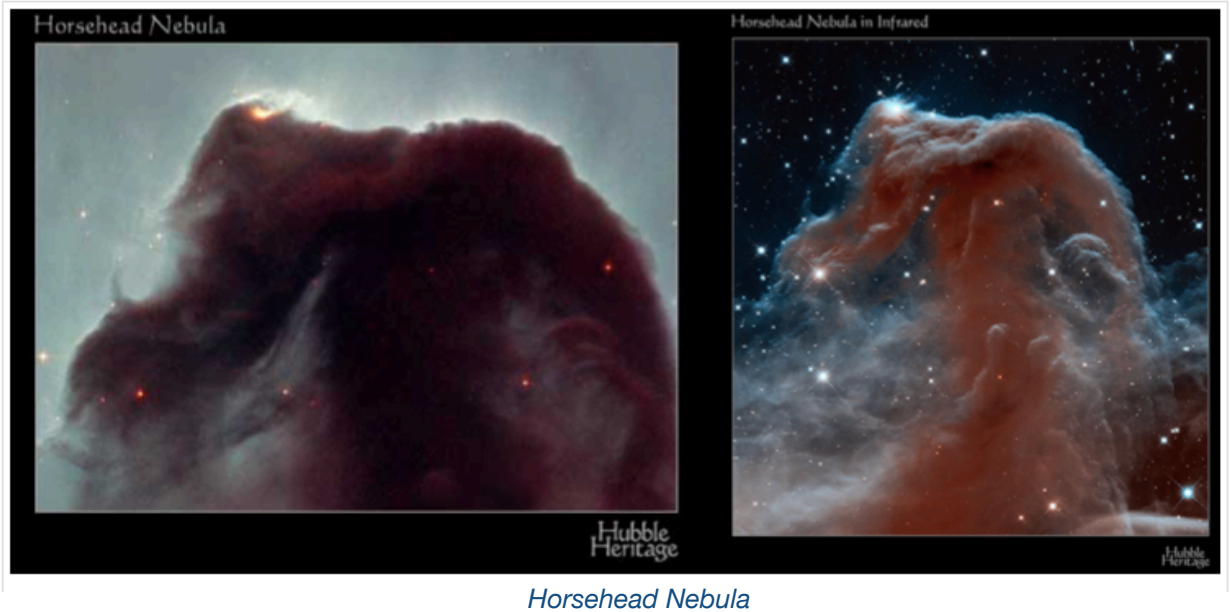
Introduction

NGC 4013



Thackeray's Globules in IC 2944

NGC 1999

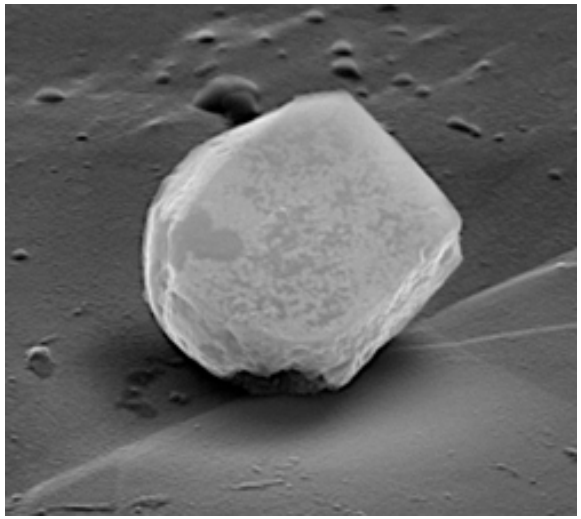


Horsehead Nebula

Introduction

Dust size ~ 100 nm

Carbon, silicon, magnesium, iron, and oxygen



Cosmic dust

M78

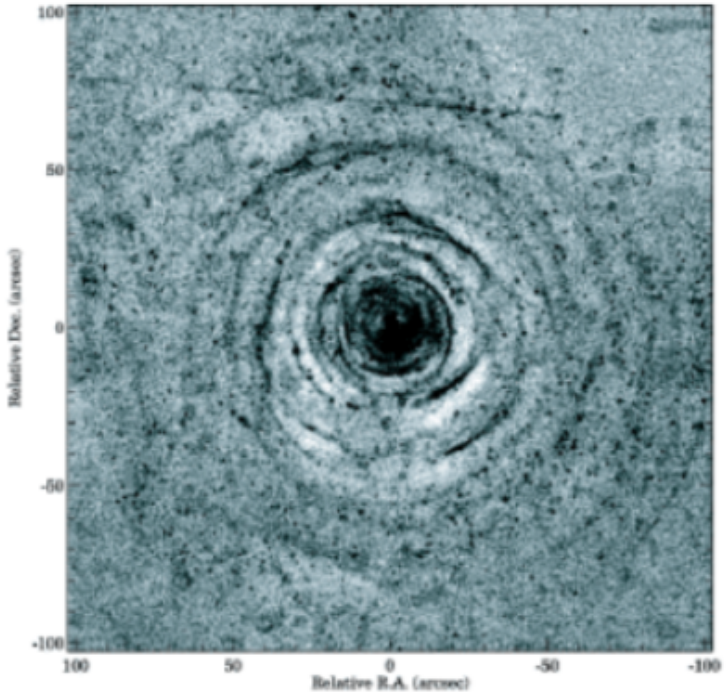
Aim

What is the mechanism of dust production at z>6?

Environment:
- high density
- low temperature

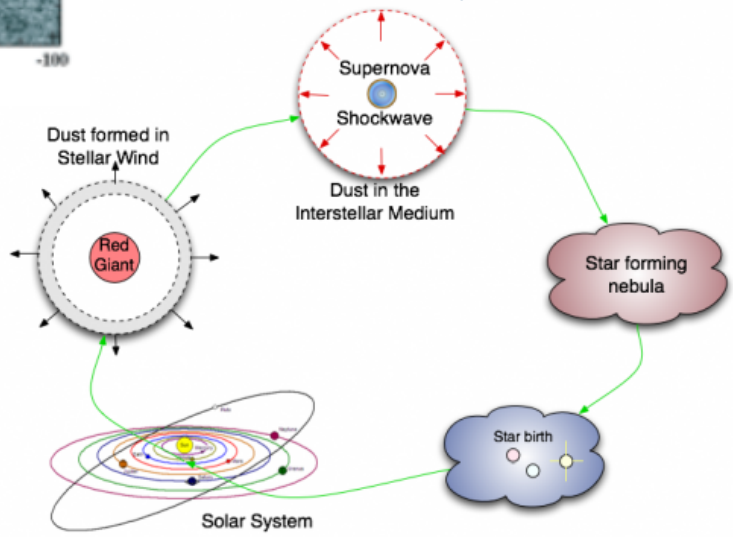
Stellar sources:
- AGB stars
- SNe

Non-stellar sources:
- grain growth in the ISM
- ?



Concentric shells of dust

Cosmic dust cycle



Sample & methodology

Table 1. List of physical properties of the galaxies in our sample.

	z	M_{dyn} (10^{10} $M_\odot$)	M_{dust} (10^7 $M_\odot$)	M_{gas} (10^{11} $M_\odot$)	$M_{stellar}$ (10^9 $M_\odot$)	Ref
HATLAS	6.027	2.6	19±4 42±7	0.16±0.06	—	1
HIMIKO	6.595	1.168 †	<0.16 †	—	35^{+15}_{-26}	2, 3
CR7	6.604	—	—	—	20	4
CR7 Clump A	6.601	3.9±1.7	<0.81	—	—	5
CR7 Clump C-2	6.598	2.4±1.9	<0.81	—	—	5
SPT0311-58E	6.9	7.7 †	40±20	0.4±0.2	35 ±15	6
SPT0311-58W	6.9	54.222 †	250±160	2.7±1.7	—	6
SXDF	7.2	5	<0.29 †	—	$0.347^{+0.616}_{-0.166}$	7
J1342+0928	7.54	<15 <3.2	24.5±18.5	<0.12	—	8
MACS0416_Y1	8.3118	—	0.36±0.07 0.82±0.16	—	$4.8^{+6.8}_{-1.8}$ $5.1^{+7.1}_{-4.9}$	9
A2744_YD4	8.38	—	$0.55^{+1.96}_{-0.17}$	—	$1.97^{+1.45}_{-0.66}$	10

References. † indicates the value determined in this work. (1) Zavala et al. (2018); (2) Carniani et al. (2018); (3) Ouchi et al. (2009); (4) Sobral et al. (2015); (5) Matthee et al. (2017); (6) Marrone et al. (2018); (7) Inoue et al. (2016); (8) Venemans et al. (2017); (9) Tamura et al. (2018); (10) Laporte et al. (2017).

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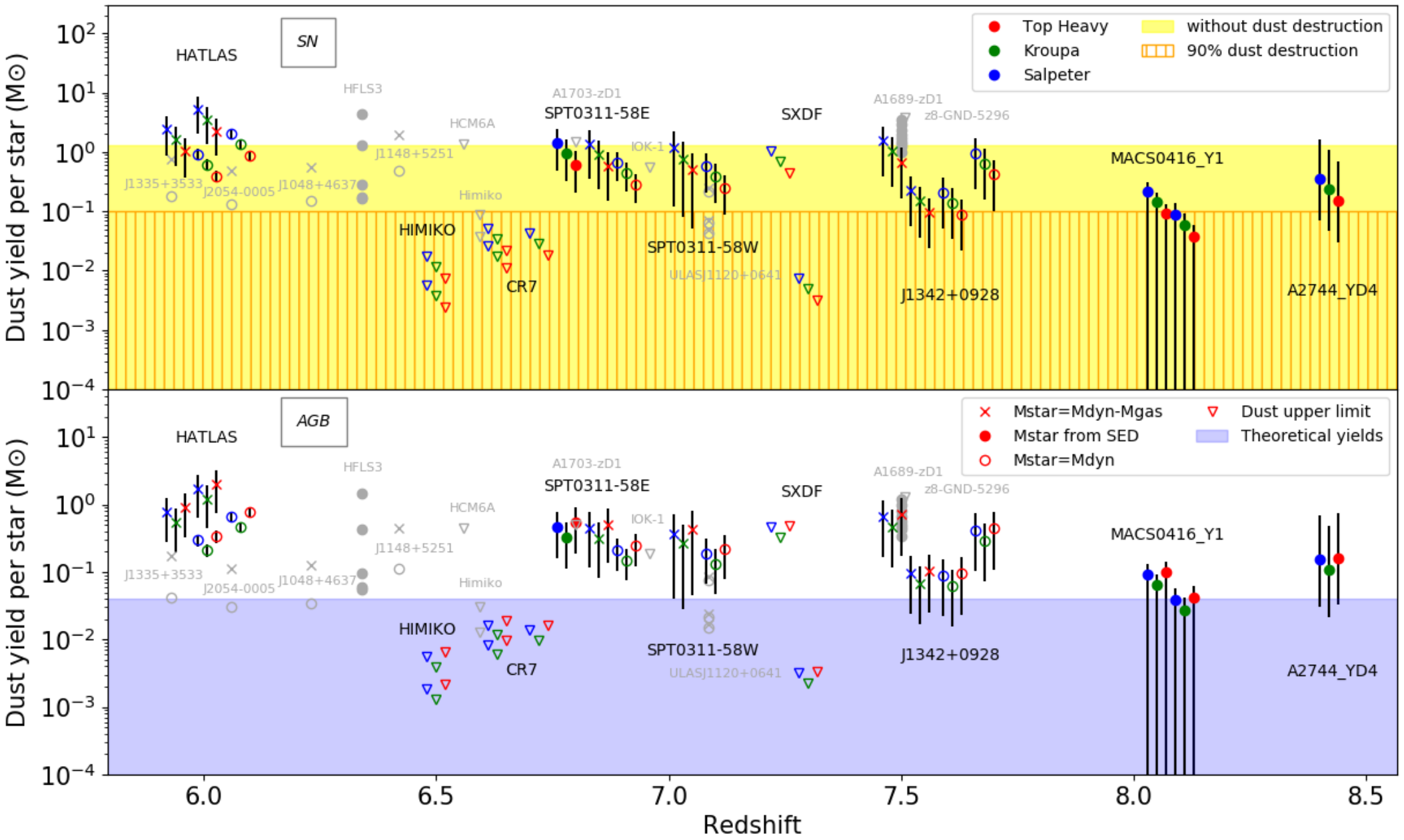
Dust Yield per star = M_{dust}/N(M_0–M_1)

Required dust yields per star at z>6



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Conclusion

1. AGB stars were not able to produce observed dust.

2. SNe could produce dust efficiently as long as they do not destroy it by shocks.

3. Non-stellar mechanism was responsible for dust presence:

    - grain growth in the ISM.

Thank You!