SFIG Group at PMO



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Evidence of Cloud-Cloud Collision in S235 Complex

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Basic scenario of cloud-cloud collision introduced by Habe & Ohta (1992)



1. Background

$ \begin{bmatrix} \times 10^3 \text{ M}_{\odot} \end{bmatrix} \begin{bmatrix} \times 10^{22} \text{ cm}^{-2} \end{bmatrix} \begin{bmatrix} \text{km s}^{-1} \end{bmatrix} \text{ distribution feature age O stars} \\ \hline (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) & (9) \\ \hline (1) & (2) & (3) & (10, 1) \\ \text{NGC 3603} & (70, 10) & (10, 10) \\ \text{NGC 3603} & (70, 10) & (10, 10) \\ \text{Westerlund 2} & (90, 80) & (20, 2) \\ \text{DBS2003 179} & (200, 200) & (8, 5) \\ \text{ONC (M 42)} & (20, 3) & (20, 1) \\ \text{NGW 120} & (50, 4) & (3, 0.8) \\ \text{N159W-South} & (9, 6) & (10, 10) \\ \text{N159W-South} & (5, 7, 8) & (4, 4, 6) \\ \text{N20} & (1, 1) & (1, 1) \\ \text{L 1188} & (1, 2, 2.7) & (1, 1.2) \\ \text{L 1188} & (1, 2, 2.7) & (1, 1.2) \\ \text{S 235} & (10, 10) & (3, 3) \\ \text{M 20} & (10, 10) \\ \text{M 20} & (11, 10, 11, 1) \\ \text{M 20} & (10, 10) \\ \text{M 20} &$	Name	cloud mass	column density	relative velocity	complementary	bridge	cluster	number of	reference	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		$[\times \ 10^3 \ M_\odot]$	$[\times \ 10^{22} \ {\rm cm}^{-2}]$	$[\mathrm{km}~\mathrm{s}^{-1}]$	distribution	feature	age	O stars		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	RCW 38	(20.3)	(10, 1)	12	no	VPS	~0.1	~20	[1]	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	NGC 3603	(70, 10)	(10, 10)	15	no	Ves	~2	~30	[2] Superstar	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Westerlund 2	(00, 80)	(20, 2)	16	10	yee	~2	14	Super star	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	DBS2003 170	(200, 200)	(20, 2)	20	yes	yes	~2	> 10	clusters	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	ONC (M 42)	(200, 200)	(0, 0)	20	yes	yes	~ 1	> 10	[6]	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	ONC (M 42)	(20, 3)	(20, 1)	~7	yes	по	< 1	~10	[0]	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	ONC (M 43)	(0.3, 0.2)	(6, 2)	~(2·	~20 km/s	no	< 1	1	🗋 🛄 Typical HII	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	RCW 120	(50, 4)	(3, 0.8)	20	yes	yes	~0.2	1	regions	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	N159W-South	(9, 6)	(10, 10)	~8	no	no	~0.06	1		
$\frac{M 20}{L 1188} (1.2, 2.7) (1, 1.2) = \frac{7.5}{22} = \frac{10}{10} \text{ mo} \text{ yes } \sqrt{2} = \frac{10}{11} \text{ termediate-} \frac{10}{11} $	N159E-Papillon	(5, 7, 8)	(4, 4, 6)	~9	no	no	~ 0.2	1	Low- or	
$\frac{1188}{S 235} (10, 10) (3, 3) = \frac{2}{5} = \frac{100}{yes} = \frac{100}{yes} = \frac{100}{10} = \frac{111}{100} = \frac{1110}{100} = \frac{1111}{100} = \frac{11111}{100} = \frac{11111}{100} = \frac{11111}{100} = 111$	M 20	(1, 1)	(1, 1)	7.5	yes	yes	~ 0.3	1	¹⁰ Intermediate	_
$\frac{S 235}{10, 10} (10, 10) (3, 3) \underbrace{5}_{\text{yes}} yes \underbrace{\sim 1}_{\text{ASTE}} 1 \text{ This Stock Tormation}$	L 1188	(1.2, 2.7)	(1, 1.2)	~ 2	no	yes	~ 1	0		
CW 120 1 1pc 1pc 0 (C) (B) (A? ASTE 1188	S 235	(10, 10)	(3, 3)	5	yes	yes	~1	1	This Swork Tormatic	n
BR3 BR3 BR2 BR2 BR2 BR2 BR2 BR2 BR2 BR2	CW 220 6 6 5a 5a 4north 4 3	7a1 7a2 7a1 7a2 7a 10 10 10 8	Ipc	(C) BR3	(B) (A) AS BR2 14 - +4.0 km/s (min. 30) ele	3.5 4 4.5 5	L 11	.88 •••••••••••••••••••••••••••••••••••		
348.4 348.3 348.2 348.1 02 ^m 35 ⁵ 25 ⁵ 15 ⁵ 106.5 106 105.5 105	348.4 348.3 Galactic Longitud	348.2	^{348.1} h 02 ^m 35 ⁵	25 ^S	+5.5 - +7.0 km/s (min. 8, st 15 ⁵	ip 5).	106.	5 106	105.5 105 e (degree)	

Examples of collision



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.5 **-**5b1

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Table 1. Comparisons between the cloud-cloud collision regions.

Color composite image of S235 complex.



CO, 13CO, C18O (1-0) are from PMO-14m

2.Collision Evidence in S235

Evidence 1: 5 km/s velocity separation.

Evidence 2: velocity bridge features



Galactic Longitude

Evidence 3: colliding interface: velocity dispersion grater than 2 km/s



Evidence 4: complementary distribution in different wavelengths



3.Summary

- 1. **5 km/s velocity separation** of blue-shifted and redshifted cloud shows the colliding motion of S235-main and S235-AB.
- 2. The velocity bridge features connecting the two clouds indicate current colliding process.
- 3. The colliding interface can be traced by complementary morphology, large velocity gradients and high velocity dispersion of two clouds.
- 4. The complementary distribution between the two clouds and ionized gas support physical interaction between them.

4. Future work

- Propose JCMT CO 3-2 observations toward S235. mapping size: 30' x 25' goal: probe the excitation condition and density properties of the colliding interface with LVG analysis.
- > Star formation triggered by cloud-cloud collision.

