Physical Conditions in the LMC's Quiescent Molecular Ridge

Molly Finn, University of Virginia
Remy Indebetouw, Kelsey E. Johnson, Allison H. Costa, C.-H. Rosie Chen, Akiko Kawamura, Toshikazu Onishi, Jürgen Ott, Marta Sewilo, Kazuki Tokuda, Tony Wong, and Sarolta Zahorecz

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Molecular Ridge:

- Contains $\frac{1}{3}$ of all CO-bright molecular gas in LMC
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- Primarily forming low- and intermediate-mass clusters, below predictions from scaling relations
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What physical conditions in the Ridge differ from the conditions in the massive star forming regions to its north?
Molecular Ridge:

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Is the Ridge not forming massive stars due to turbulence or magnetic support? Or does it lack dense gas?

predictions from scaling relations
ALMA ACA map of $^{13}$CO(1-0) at 13" (~3 pc) resolution
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Compare to dendrogram structures in 30 Dor, N159, and N113
Size-linewidth relation

\[ \sigma_v = a_1 R^{a_2} \]
Size-linewidth relation

\[ \sigma_v = a_1 R^{0.5} \]
Size-linewidth relation

→ At a given size scale, the Ridge has less kinetic energy than 30 Dor, N159, and N113

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Finn et al. (in prep)
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We can rule out turbulent support limiting star formation in the Ridge
Virial equilibrium: balance between potential and kinetic energies.
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Virial equilibrium: balance between potential and kinetic energies

\[ \alpha_{\text{vir}} = \frac{5\sigma_v^2 R}{GM} \]
The Ridge has higher virial parameter than 30 Dor, despite its low kinetic energy

Finn et al. (in prep)
The Ridge has higher virial parameter than 30 Dor, despite its low kinetic energy

→ Needs low potential energy as well

Finn et al. (in prep)
High virial parameter appears to be driven by low surface density

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Low star formation in the Ridge could be due to a lack of dense gas.
High virial parameter appears to be driven by low surface density

Low star formation in the Ridge could be due to a lack of dense gas

Cannot conclude why the gas might be low density, cannot rule out magnetic support
High virial parameter appears to be driven by low surface density

Low star formation in the Ridge could be due to a lack of dense gas

Connection to interactions with the SMC?
Fitting RADEX Models

- Want to minimize* assumptions about the physical conditions of the gas
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- Perform pixel-by-pixel fits to create maps of temperature, volume density, and column density

Finn et al. (2021)
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- Need multi-line observations with range of excitation parameters

Finn et al. (2021)
Fitting RADEX Models

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- Perform pixel-by-pixel fits to create maps of temperature, volume density, and column density
- Need multi-line observations with range of excitation parameters:
  \(^{12}\text{CO}(1-0), ^{12}\text{CO}(2-1), ^{13}\text{CO}(1-0), ^{13}\text{CO}(2-1)\)
Differs from LTE calculations of mass and temperature by as much as 66%
Match embedded YSOs to CO clumps

Finn et al. (2021)
The presence of YSOs in the Ridge is correlated with RADEX-fitted $n_{H_2}$
The presence of YSOs in the Ridge is correlated with RADEX-fitted $n_{H_2}$.
Also correlated with total mass and average mass of YSOs

Finn et al. (2021)
(a) $r: 0.37$

Finn et al. (2021)
Finn et al. (2021)
RADEX-fitted volume density uniquely captures physical conditions

Finn et al. (2021)
Volume and surface density not particularly correlated
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\[ r = -0.31 \]
Volume and surface density not particularly correlated

Need to perform RADEX fitting in other regions to compare physical conditions

Finn et al. (2021)
Summary and looking forward

- Quiescent Molecular Ridge in the LMC is most likely not forming massive stars because it lacks sufficiently dense gas and not because it is supported by turbulence.
- Fitting RADEX models to CO emission can uniquely determine physical conditions that correlate with star formation.
- We will expand out RADEX fitting to other regions and other sets of molecular lines to compare physical conditions in different galactic environments.