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Starbursts triggered by central overpressure in interacting galaxies

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Abstract. We present a triggering mechanism for starbursts in the central regions of interacting galaxies. As a disk giant molecular cloud (GMC) falls into the central region of a galaxy following a galaxy encounter, it may be compressed by the high pressure of the inter-cloud medium. For a high enough pressure difference, the compression develops into an inwardly propagating, isothermal, spherical shock. When the growth time for gravitational instabilities in the shell become smaller than the crossing time of the shell, the shell becomes unstable and begins to fragment. This gives rise to a burst of star formation. For a galaxy with pre-encounter gas parameters as in the Galaxy, this mechanism yields a lower limit to the infra-red luminosity of $L \sim 2\text{-}6 \times 10^9 L_\odot$. For strong interactions or mergers $L_{IR} \leq 10^{12} L_\odot$ (Jog & Das 1992).

Key words : galaxies—starbursts

1. Gas infall and cloud compression

The mechanism begins with the infall of disk gas to the central region. It is well established (e.g. Norman 1992) that galaxy interactions or a bar instability result in gas infall from the disk to the nuclear region of a galaxy. We consider a Giant Molecular Cloud (GMC) which has fallen into the nucleus. Also, recent observations have shown the existence of a fairly uniform, gaseous (molecular) inter-cloud medium (ICM) in the central 1 Kpc region of the Galaxy (Bally *et al.* 1988). The average pressure in the nuclear ICM is found to be about 30 times greater than the internal pressure within a disk GMC.

A disk GMC will be compressed by the nuclear ICM if $P_{ICM} > P_{GMC}$. For a high enough pressure difference, the compression develops into an inwardly propagating, isothermal, spherical shock. The shocked shell of gas becomes gravitationally unstable when the instability growth time t_g is smaller than the shell crossing time t_c. The shell begins to fragment leading to a burst of star formation in the fragmented shell.

2. Enhanced star formation and resulting IR luminosity

For gas parameters of our Galaxy, $P_{ICM}/P_c \sim 30$ and $t_g = t_c$ at $r = 0.47\ R_c$, where R_c is the GMC radius. Thus about 78% of the cloud mass is compressed. The star formation in the high density gas of the shocked shell of the GMC is characterised by high star formation efficiency and the preferential formation of massive stars of a few $M_\odot$ each (Larson 1986). The resulting IR luminosity L_{IR} depends linearly on the gas infall rate, the cloud mass fraction compressed, and the star formation efficiency. Our mechanism yields a lower limit L_{IR} ~a few times 10^9 $L_\odot$ and $L_{IR}/M_{gas} \sim 1$ $L_\odot/M_\odot$. This is in a reasonably good agreement with observations of central starbursts in tidally interacting galaxies. The evolved mergers, with their high gas infall rate, yield high values of $L_{IR} \sim 10^{12}$ $L_\odot$ and $L_{IR}/M_{gas} \sim 100$ $L_\odot/M_\odot$ respectively, which agree with the observed values of the central regions of evolved mergers.

3. Discussion

Not all interacting galaxies show starburst. One reason may be that the galaxy does not have a high pressure ICM. Thus we can explain why M33 does not show a central starburst despite a bar and the close interaction with M31. More observational data for the central ICM pressure in spiral galaxies are needed to check if the triggering mechanism proposed here is applicable to these galaxies.

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