Resonance phenomena in light heavy-ion collisions are well established for composite systems with masses below 60. While it is understood that the observation of resonances depends on the number of open reaction channels, their relation to large cluster (molecular) states in the composite system is still a debated question. The firm identification of these resonances with nuclear molecules relies strongly on a detailed study of their various decay modes and in particular on their fragment and gamma decay widths. The heavy-ion resonances correspond to high excitation energies in the composite systems where the density of states is large. The best cases to study are those for which the resonance width and thus also the spreading width are small. The $^{12}\text{C} + ^{12}\text{C}$ and $^{12}\text{C} + ^{16}\text{O}$ reactions on one hand and the $^{24}\text{Mg} + ^{24}\text{Mg}$ reaction on the other hand are two examples where similar narrow width resonances ($\Gamma = 100 - 200$ keV) have been observed under rather different conditions: around the Coulomb barrier and with low spins for $^{12}\text{C} + ^{12}\text{C}$ and $^{12}\text{C} + ^{16}\text{O}$, at twice the Coulomb barrier and high spins for $^{24}\text{Mg} + ^{24}\text{Mg}$. For the heavier $^{24}\text{Mg} + ^{24}\text{Mg} \rightarrow ^{48}\text{Cr}$ case, the narrow resonances correspond to much higher excitation energies in the composite system and thus the proposed studies have to be more devoted to the fragment and particle decay channels. The experimental programme underway for this system* at the Legnaro Tandem will be presented in another contribution to this conference [1].

For the lighter $^{12}\text{C} + ^{12}\text{C} \rightarrow ^{24}\text{Mg}$ and $^{12}\text{C} + ^{16}\text{O} \rightarrow ^{28}\text{Si}$ cases, we will show that the most promising research programme underway concerns the study of the resonant radiative capture reactions $^{12}\text{C}(^{12}\text{C},\gamma)^{24}\text{Mg}$ and $^{12}\text{C}(^{16}\text{O},\gamma)^{28}\text{Si}$ and the search for enhanced $\gamma$ decay through specific doorway states [2]. In the present contribution, we will focus on the case of the $^{12}\text{C} + ^{16}\text{O}$ reaction where the radiative capture cross-section is resonant around $E_{\text{Lab}}(^{16}\text{O}) = 20$ MeV [3]. The origin of the observed resonances is unclear: population of $^{28}\text{Si}$ cluster states and/or population of the GDR built on low-lying $^{28}\text{Si}$ states. We will present the results of the $^{12}\text{C}(^{16}\text{O},\gamma)^{28}\text{Si}$ experiment performed recently at Triumf (Vancouver) using the 0 degree recoil spectrometer Dragon [4] and an associated BGO $\gamma$ array. We will discuss in particular the importance of multistep decay feeding doorway $^{28}\text{Si}$ quasi-bound cluster states which are predicted theoretically [5]. Such types of decay and feeding have been discovered recently in the case of $^{24}\text{Mg}$ populated through the resonant $^{12}\text{C}(^{12}\text{C},\gamma)^{24}\text{Mg}$ radiative capture reaction [2].

* In collaboration with the Legnaro-Padua Prisma-Clara and Gasp-Euclides groups.

References

[1] M.-D. Salsac et al., contribution to Fusion06.


