5. DISCUSSION AND CONCLUSION:

Table II, which contains the $\chi^2$ values for the fit to the experimental data, shows that the potentials $S-\delta$, $SE$, and $SRM$ are quite close to the effective interactions of Cohen et al.\textsuperscript{18} and that of Auerbach\textsuperscript{19}, while the Hamada-Johnston potential\textsuperscript{15} is slightly weaker, and the Tabakin potential\textsuperscript{14} is still worse.

An examination of Table III, containing $\lambda, \Lambda, \Sigma$, and $V$, reveals that the $S-\delta$ potential is very close to the $EIC$ and $EIA$, while the $SE$ is slightly stronger and the $SRM$ is slightly weaker. Both $SE$ and $SRM$ give the same spins of the lowest quasiparticle state, which is different in some cases from that predicted by $S-\delta$, $EIC$, and $EIA$. The corresponding values of $HJ$ and $TP$ are quite different, but essentially show the same qualitative features. The overlap of the projected BCS wave function with the exact shell-model ground-state wave function for $^{58}\text{Ni}$ is very poor and has not been shown here. Because the number of nucleons treated for $^{60}\text{Ni}$ is only two, the accuracy of the pairing solution is very doubtful, and therefore this poor overlap is not very surprising. But for $^{60}\text{Ni}$ the overlap is fairly good, as is clear from the Table IV.

Fig. 3 again reflects that the $S-\delta$ is very close to the $EIC$ and the $EIA$, while the $SE$ and $SRM$ are slightly off, but the $HJ$ and $TP$ are too weak to be compared.

These conclusions on the effective potential have been utilised in our quasiparticle calculation for all the even $\text{Ni}$ isotopes based on the MTDA formalism presented in Part II of this thesis.
A final comment is warranted here on the HJ and TP potentials. Since the HJ is an exact two-nucleon potential, one has to be very careful about calculating its effective matrix elements for shell-model work. In particular, it has been emphasised by Kuo and Brown\textsuperscript{29} that the core-polarisation effects are very important in this type of calculation. Since in our work we assumed the $1f_{7/2}$ level to be full, while in reality excitations can very easily take place from this level to the $1f_{5/2}$, $2p_{3/2}$, and $2p_{1/2}$ levels, and also the excitation from $1f_{5/2}$, $2p_{3/2}$, and $2p_{1/2}$ levels to the nearby $1g_{9/2}$ level, the use of $t$-matrix elements with the inclusion of core-polarisation effects was very vital. Such matrix elements to be used in the Ni region have recently been reported by Kuo\textsuperscript{20}. Unfortunately, the HJ $t$-matrix elements used in our present work were deficient in this respect, and hence the inadequacy of the HJ potential, found here, is not surprising. Kuo’s matrix elements have been already used by Lawson et al.\textsuperscript{21} to perform the calculation for all Ni isotopes. A similar remark is true about the Tabakin potential, for a different reason. It has been shown\textsuperscript{30} recently that there is a fairly significant second-order contribution to the Tabakin matrix elements for shell-model work. Our work, as reported here, did not use these additional contributions.

In the testing stages of our quasiparticle calculations by MTDA formalism we had been using all the above mentioned effective two-nucleon potentials, and the pairing plus quadrupole interaction used by Kisslinger and Sorensen\textsuperscript{5}, Bareniger\textsuperscript{6}, and various other workers.
The identification of the 2.78 MeV level in $^{58}$Ni as $0^+$ by Auerbach and Cohen et al. has been found to be incorrect in more recent work, which establishes this level to be $2^+$. This means that the EIC and EIA matrix elements for the $0^+$ states will need modification. Although Kuo's $t_{\pi}$ matrix elements were found to be reasonably good in the work of Lawson et al., there is still some discrepancy with EIC and EIA. For this reason we decided to use the EIC and EIA semiphenomenological sets of the effective two-body matrix elements, rather than a set which has got better theoretical foundation. We also used the pairing plus quadrupole interaction which has been commonly used in the quasiparticle calculations.