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ON ELECTRON TRANSPORT IN LOCALLY PERIODICAL WAVEGUIDES

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The work is devoted to electron transport in two-dimensional waveguides with variable cross-section. We are interested in constructing waveguides where electrons cannot propagate if their energies belong to some prescribed intervals. If a waveguide is locally close to a strip with respect to a small parameter (S-waveguides), there are several methods that enable us to describe the asymptotic expansion for the electron wave-function. For example, these methods show that, for the S-waveguides with one narrow, the electrons with transverse energies greater than a critical value pass through the waveguide without evident reflection, and the other electrons are almost completely reflected. The points on an S-waveguide “axis” where the transverse energy of an electron coincides with the critical value are called turning points.

We develop an asymptotic theory for a wider class of waveguides. We suppose that a waveguide is locally close to a periodic one with respect to a small parameter (P-waveguides). We also assume that a P-waveguide coincides with the union of two semi-strips outside a compact set. We generalize the technique elaborated for one-dimensional Schrödinger operators by V. Buslaev and A. Grigis [1], and use the main ideas from their work in our constructions. This technique enables us to construct the uniform asymptotic solutions in a whole P-waveguide (and an S-waveguide) even if the waveguide contains several turning points. In particular, we describe the uniform asymptotic solutions for P-waveguides (and S-waveguides) that contain two close turning points.

We consider several model situations: waveguides with one, two or four turning points. From the physical point of view, if a waveguide contains only one turning point, the electron motions in S- and P-waveguides are quite similar. In the both cases an electron whose transverse energy is greater than a critical value passes through the waveguide without reflection. In the presence of two turning points, there is an essential distinction between the S- and P-waveguides. The zone between turning points plays the role of a potential barrier in the both types of waveguides. However, there is a possibility to create such a barrier in any interval of energy for a P-waveguide which is not the case for an S-waveguide. In the presence of four turning points there occur two restricted zones. The region between such two zones plays the role of a resonator. If the energy of an electron is close to a resonator eigenfrequency, then the electron can pass through the barrier (“resonant tunnelling”).

REFERENCES

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