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The von Neumann representation for ultrashort laser pulses

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The representation of ultrashort laser pulses in time or frequency domain limits the interpretation to the respective domain, e.g. for a given temporal intensity various frequency contents of the pulse are possible that are not easily discernible. A more intuitive picture is given by joint time frequency representations (JTFR) that simultaneously show both temporal and spectral features. Especially when using adaptive quantum control in combination with pulse shaping this type of representation can help to identify the main features in the resulting often rather complex pulse(-train)s.

The most commonly used distribution functions, namely the Wigner [1] and the Husimi [2], have the disadvantage compared to the conventional representation of the electric field as intensity and phase that the number of data points necessary to describe the field grows quadratically with the number of sample points in time or frequency.

An idea for reducing the information down to the essential content is based on an idea by von Neumann [3] which states that the minimal unit of information in phase space is constant and hence the number of points for the JTFR should not be larger than for the representation in frequency domain.

We present an implementation of this idea for the representation of ultrashort laser pulses as well as a discussion of the advantages and disadvantages of the von Neumann representation in comparison with the other possible representations.

References:
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[2] K. Husimi, Proc. Phys.-Math. Soc. Jpn. **22**, 264 (1940)
[3] J. v. Neumann, Math. Ann. **104**, 570 (1931)