[T1]

A square matrix A is normal iff it commutes with its (Hermitian) adjoint, i.e.

$$AA^* - A^*A = O$$

This can be shown to be equivalent to be orthogonally diagonalizable, i.e.

$$\exists U \in \mathcal{U}(n), U^*AU\colon \text{ diagonal}$$

(here $\mathcal{U}(n)$ denotes the n-by-n unitary matrix)

[T2]

(a) True, since their adjoint is the same as themselves.
(b) False; consider identity matrix.
(c) True, since the characteristic polynomial will be real in the case of real matrices, and the complex roots of a real-coefficiented polynomial always come in complex conjugate pairs.
(d) True; consider $A = \begin{bmatrix} 0 & i \\ i & 0 \end{bmatrix}$ which is symmetric (but complex); its characteristic polynomial is $p(\lambda) = \lambda^2 + 1$ and the eigenvalues are $\pm i$.
(e) True; consider $A = I$ or $A = iI$.
(f) False; consider $A = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$ the unital Jordan block.
(g) True, since determinant admits matrix commutation, similar matrices shall have the same characteristic polynomials.

[T3]

(a) No; the iteration could swing between v_1 and v_2; for example, consider the case

$$A = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, x^0 = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

then each iteration just swings between the two unit vectors $\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -1 \end{bmatrix}$ and doesn't converge at all. For a more sophisticated counterexample, decompose the given matrix

$$A = P \left(\lambda_1 \begin{bmatrix} K & O \\ O & D \end{bmatrix} \right) P^*$$

where $P \in \mathcal{U}(n)$ (the set of unitary n-by-n matrices), $K = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ and D is a $(n-2) \times (n-2)$ diagonal matrix with $\rho(K) < 1$. Identically, the power method diverges with

$$x^0 = P \begin{bmatrix} 1/\sqrt{2} \\ 1/\sqrt{2} \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

(b) No; with the same decomposition of A and denote

$$x^0 = P \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}$$

Consider the case $a_1 = a_2 = 0$, then the power method applied on A would be degenerated into that applied on the submatrix D, and certainly nothing computed in this case could relate to the largest eigenvalue λ_1 or λ_2. (I'm just throwing out the most absurd counterexample...)

(c) No; the reason is the same as above.

The above absurd counterexample might seem too sloppy in making productive arguments. To elaborate, denote $\mu_{k+1} = \|Aq^k\|$, then the iteration becomes

$$\begin{aligned}
&\mu_0 = \|x^0\|; q^0 = \frac{1}{\mu_0} x^0; \\
&\text{for } k = 0, 1, \cdots \\
&x^{k+1} = Aq^k; \mu_{k+1} = \|x^{k+1}\|; q^{k+1} = \frac{1}{\mu_{k+1}} x^{k+1};
\end{aligned}$$

and

$$q^{k+1} = \left(\prod_{j=0}^{k+1} \frac{1}{\mu_j} \right) A^{k+1} x^0$$

here $\prod_{j=0}^{k+1} \frac{1}{\mu_j}$ is just a coefficient normalizing the vector q^{k+1}; therefore,

$$\begin{aligned}
q^k &= \left(\prod_{j=0}^{k} \frac{1}{\mu_j} \right) A^k x^0 \\
&= \left(\prod_{j=0}^{k} \frac{1}{\mu_j} \right) P \begin{bmatrix} \lambda_1^k a_1 \\ \lambda_2^k a_2 \\ \vdots \\ \lambda_n^k a_n \end{bmatrix} \\
\|q^k\|^2 &= \left(\prod_{j=0}^{k} \frac{1}{\mu_j^2} \right) \sum_{i=1}^{n} |\lambda_i^k a_i|^2 = 1
\end{aligned}$$

Now examine the scalars

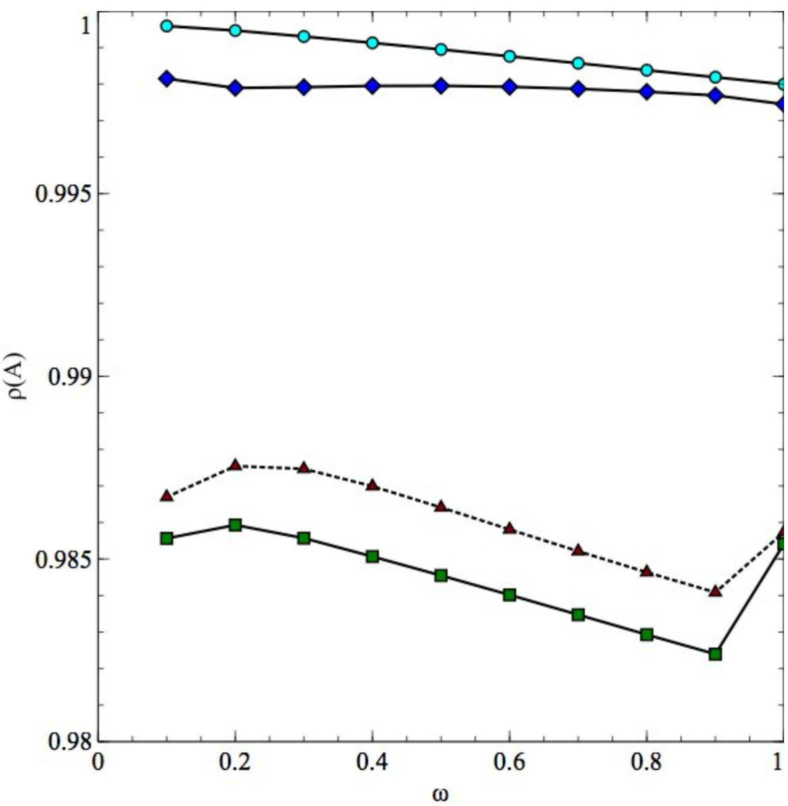
$$\langle q^k, Aq^k\rangle = \left(\prod_{j=0}^{k}\frac{1}{\mu_j}\right)^2 \left[\begin{array}{cccc}\bar{\lambda}_1^k\bar{a}_1 & \bar{\lambda}_2^k\bar{a}_2 & \cdots & \bar{\lambda}_n^k\bar{a}_n\end{array}\right] P^*P\begin{bmatrix} K & O \\ O & D\end{bmatrix} P^*P \begin{bmatrix}\lambda_1^k a_1 \\ \lambda_2^k a_2 \\ \vdots \\ \lambda_n^k a_n\end{bmatrix}$$

$$= \left(\prod_{j=0}^{k}\frac{1}{\mu_j}\right)^2 \sum_{i=1}^{n}\lambda_i|\lambda_i|^{2k}a_i = \frac{\sum_{i=1}^{n}\lambda_i|\lambda_i^k a_i|^2}{\sum_{i=1}^{n}|\lambda_i^k a_i|^2}$$

$$\sqrt{\langle Aq^k, Aq^k\rangle} = \prod_{j=0}^{k}\frac{1}{\mu_j}\sqrt{\sum_{i=1}^{n}|\lambda_i^{k+1}a_i|^2} = \sqrt{\frac{\sum_{i=1}^{n}|\lambda_i|^2|\lambda_i^k a_i|^2}{\sum_{i=1}^{n}|\lambda_i^k a_i|^2}}$$

Therefore, with the given convergence, and an additional condition that there's one and only one of a_1 and a_2 that is zero (to exclude the case of the above absurd counterexample), then $\langle q^k, Aq^k\rangle$ can converge to the (possibly) complex eigenvalue with the largest magnitude, and $\sqrt{\langle Aq^k, Aq^k\rangle}$ can converge to the absolute value of it.

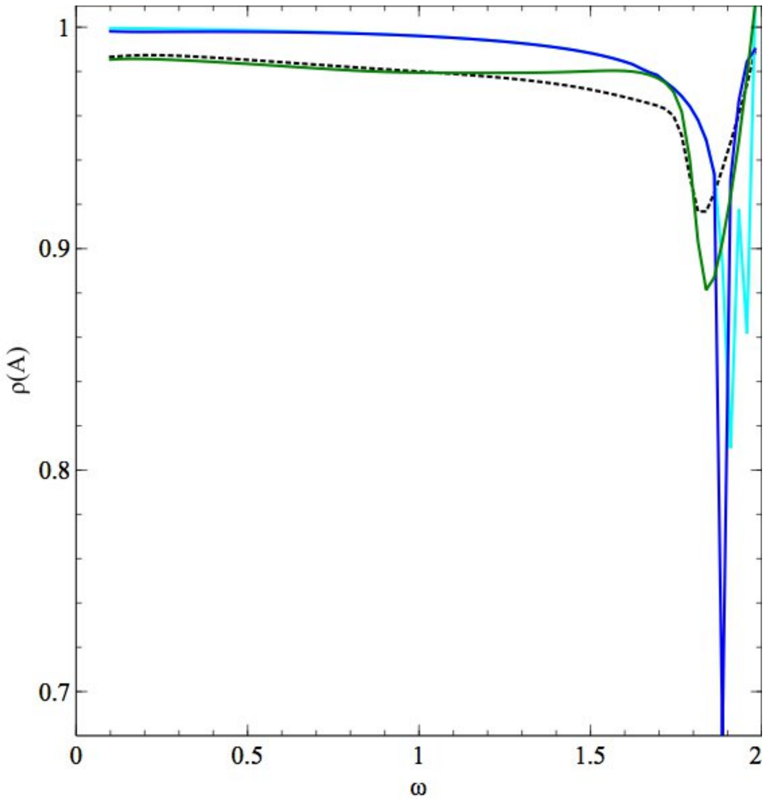
[C3/4]



▲ Gauss-Jacobi Method
green (40 iterations, 50×50 grid)
blue (400 iterations, 50×50 grid)

cyan (2,000 iterations, 50×50 grid)
black (40 iterations, 50×100 grid)

From the green line (with 50×50 grid), we can suggest $\omega = 0.9$ to be the optimal parameter of the Gauss-Jacobi method; by observing the green (40 iterations), blue (400 iterations) and cyan (2,000 iterations) lines, we see the optimal parameter changed from $\omega = 0.9$ to $\omega = 1$ when we increased the iterations.
From the red dash line we can see the optimal parameter for a 50×100 grid is also $\omega = 0.9$ (when 40 iterations are used).



▲ SOR Method
green (40 iterations, 50×50 grid)
blue (400 iterations, 50×50 grid)
cyan (2,000 iterations, 50×50 grid)
black (40 iterations, 50×100 grid)

(TBH I inspected the .csv file to get the accurate digits for SOR results..)
From the green line, we can suggest $\omega = 1.84$ to be the optimal value of the Gauss-Jacobi method; by observing the green (40 iterations), blue (400 iterations) and cyan (2,000 iterations) lines, we see the optimal parameter changed from $\omega = 1.84$ to $\omega = 1.88$ to $\omega = 1.91$ when we increased the iterations from 40 to 400 and to 2,000.
From the red dash line we can see the optimal parameter for a 50×100 grid is also $\omega = 1.84$ (when 40 iterations are used).